

A

MINERALOGICAL DESCRIPTION

OF THE

COUNTY OF DUMFRIES.

Patrick ——— Murray L. C. F.

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TO

A. G. W E R N E R,

THE FATHER OF MINERALOGY;

AND

RICHARD KIRWAN,

WHOSE INDEFATIGABLE EXERTIONS HAVE
CONTRIBUTED SO GREATLY TO THE
ADVANCEMENT OF MINERALOGY
IN THE BRITISH EMPIRE.

THIS VOLUME

IS DEDICATED BY THEIR OBEDIENT SERVANT,

ROBERT JAMESON.

COLLEGE OF EDINBURGH, }
Oct. 10, 1804. }

ERRATA.

Page Line

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|-----|---|-------------------------------------------------------------|-------------|
| 17 | 8 | that to be cancelled. | |
| 58 | | for drussy, | read drusy. |
| 154 | 2 | after in, add engen Räumen eingeschlossen war, wodurch ihr, | |

PREFACE.

THE Duke of Buccleugh, with his usual patriotic attention to the interests of Dumfries-shire, proposed some years ago to the landholders of the county to have a Map of it made for their use; and, with the approbation of his Grace, Colonel, now Brigadier-General Dirom of Mount Annan, suggested that a Mineral survey should also be made of the county, in order to connect a knowledge of its fossils and internal structure with the land survey which was then carrying on by Mr. William Crawford.

“The meeting unanimously approved
“of the proposal for the mineral survey,
“and voted their thanks to his Grace the
“Duke of Buccleugh for having been
“pleased to recommend it to their attention;
“and to Colonel Dirom for having
“brought forward a plan so likely to be
“useful to the county.”

Upon that occasion I was applied to by the General and by Colonel Wight

of Larnain, on the part of the county, to undertake the mineral survey; but, being on the eve of my departure for Germany, I was under the necessity of declining to enter upon such an investigation. It being, however, the principal object of the gentlemen of the county to obtain information as to the probability of finding coal in the extensive tract of country which lies between the rivers Esk and Nith, they engaged two *coal viewers* from Northumberland, Messrs. Busby, to make the survey, to whom, both the late Dr. Walker, my predecessor in the chair of natural history, and myself, gave instructions, which, together with their report, are, I understand, in the possession of the county.

Previous to my return from Germany, General Dirom had prepared a Tablet, containing sections, and exhibiting a general view of the Mineralogy of Dumfries-shire, to be printed on the map of the county, and which, in a small compass, contains much useful and interest-

ing information. But, as both the General and Colonel Wight considered what had been done as still not affording the complete information which was expected by the landholders of the county, upon this important subject, I was again requested by these intelligent gentlemen to undertake the publication of a more detailed mineralogical description of Dumfries-shire, which might accompany the county map, which was still unpublished. To this proposal I acceded with pleasure, not only from my desire to promote such useful investigations, but also from its tending to carry into effect a plan which I had long in contemplation, of examining the mineralogy of every part of Scotland, and of offering, in this manner, the result of my labours for the information of the public.

INTRODUCTION.

IN a country like Scotland, whose surface presents so great a variety of rocks, and which agrees in many respects with the most important mining countries in other parts of the world, it is evident that many considerable mineral repositories are to be expected. Its situation, the structure of its surface, and the abundance of water and coal which it possesses, render it peculiarly well adapted for carrying on with œconomy and profit the various operations of mining.

But as ores, coals, and other useful minerals are usually hid in the bowels of the earth, we must endeavour by min-

ing to trace them out; and in these researches we must follow a determinate plan, founded on an accurate local knowledge of the district where the trials are made; otherwise in excavating galleries, driving levels, sinking shafts, and putting down bore-holes, our operations will be uncertain.

These operations must be conducted with skill, and their execution should be superintended by well educated and intelligent mine-engineers.

It is an opinion too generally credited, that the art of mining is easy and simple, and that little education, and no very great share of practical knowledge is necessary for its successful prosecution. But this assertion is founded on ignorance; for of all the arts with which man is occupied, there is none which requires more preliminary knowledge or more extensive experience. A *mine engineer* must be well instructed in subterranean geo-

metry ; he must be intimately acquainted with mechanics, hydraulics, and hydrostatics, so that he may be able to judge correctly of the machines which are employed in conveying the ores from one part of a mine to the other, raising them to the surface, and stamping and washing them, also with the elegant and powerful machines used in draining mines ; he must possess as much knowledge of architecture as will enable him to superintend the construction of the various kinds of building which are employed in subterranean works, and in the erection of the different day buildings, as engine, smelting, and washing houses, and also that of canals, artificial reservoirs for water, &c. ; nor should he be ignorant of the art of carpentry, particularly that species of it which is employed in constructing subterranean works. His knowledge of mineralogy must be correct and extensive, in order to enable him to know and distinguish simple minerals, and to judge with accuracy of the

various mineral repositories ; he must be acquainted with all the branches of chemistry, but most particularly with that of metallurgy ; and he must not be indebted to lectures, books, drawings, and models alone for his knowledge ; he must have assisted for years in all the practices I have just mentioned. When this course of education is finished, he should be able conscientiously to take charge of a great mine, or to establish one in a country where there are few to assist him with knowledge or experience.

I could mention very many instances of the great loss to proprietors and states by the want of skill and experience in mine-engineers, but I shall at present mention only one, and it is very striking. In Spanish America, according to Anton Zacharias Helms, the amalgamation of the ore continues an entire month, and in each operation there is a loss of twenty-five pounds of mercury in the quintal, and a part of the silver remains in the

ore. At Freyberg the operation is finished in twenty-four hours, the loss of mercury does not exceed half an ounce, and a small quantity of silver is obtained which was not even indicated in the cupellation of the effayer. Daubiffon, a distinguished pupil of Werner, in his masterly description of the mines of Freyberg, infers very justly from this fact that the produce of the Spanish American mines might be greatly increased, nay nearly doubled*.

* As it may be interesting to some of my readers to know the actual produce of these famous mines, I here subjoin an extract from the work of Daubiffon already mentioned, containing an account of the returns made to the Spanish mint, in the year 1790.

<i>Cities.</i>	<i>Provinces.</i>	<i>In gold.</i> <i>Livres.</i>	<i>In silver.</i> <i>Livres.</i>
a. St. Jago	Chili	4,417,134	894,327
b. Potosi	Buenos-Ayres	1,833,728	24,367,668
c. Lima	Peru	5,023,616	27,768,000
d. Mexico	Mexico	3,843,629	106,706,140
		<hr/>	<hr/>
		15,118,107	159,736,135

But independent of the employment which the researches I am now engaged in will afford to the miner, by the discovery of useful minerals, it will, I trust, also prove a source of information to the mineralogist. Few countries so little explored as Scotland have afforded a greater variety of minerals, which allows us to hope that a more complete and accurate investigation will increase the number of hitherto undescribed oryctognostic products. The geognost*, will obtain new facts, and

To this sum, amounting to one hundred and seven-four million of livres, may be added the quantity of gold and silver not delivered to the mint, but which is worked for churches, convents, and other uses, which is very considerable. Thus we may reckon that there is annually raised from the mines of Spanish America the value of two hundred million livres, or fifty million rix-dollars.

* Geognosie not only makes us acquainted with the materials and structure of the crust of the earth, but also with the history of the changes which it has experienced, thus forming a most interesting branch

a more extensive generalization of those already known respecting the structure and relative position of the masses of which the earth is composed, by an examination of the unexplored wilds of Scotland.

In the Mineralogical Description of the County of Dumfries, which forms the first part of this volume, I have laid down

of *Natural History*. But it is not confined to the history of the changes which the inorganic parts of the globe have undergone; it also develops those numerous and wonderful alterations which the organic creation has experienced since it was first formed by the creator. Taken in this view, geognosie ceases to be that unconnected, vague, and useless jargon which it was before the time of Werner; it is thus raised to the rank of the most important and interesting of the sciences. It unites all the branches of natural history, (I mean natural history commonly so called, which includes natural description and the history of natural bodies,) and forms the link which connects the investigations of the naturalist with those of the astronomer, the one being employed in investigating the structure of the world, the other that of the universe.

the plan I intend to follow in all my future labours in this department of mineralogy. It is different from any hitherto proposed, but from its concordance with the principles of the Wernerian geognosie I trust it will be found calculated to give a clear, distinct, and comprehensive view of the external aspect and internal structure and materials of which a country is composed.

The Description of Dumfries-shire, which I now presume to lay before the public, is not so complete as to satisfy a well informed mineralogist; I trust, however, that although incomplete it will be found accurate. The observations which it contains, considered in an œconomical point of view, shew that many extensive tracts of the independent coal formation exist in different parts of the county; that limestone may exist in many places where it has not been hitherto expected; that from the shape of the mountains in the upper part of the

county, and the kind of rock of which they are composed, mineral repositories of different kinds, but particularly of lead ore, are to be expected; and that roof slate will be found in many parts of the transition country.

The geognostical observations make us acquainted, 1. With an extensive tract of transition rocks, a class of rocks hitherto unnoticed in Great Britain*.

* I have traced the transition rocks from the northern extremity of the Pentland hills, which is about six miles distant from the shore of the firth of Forth, to Lang-robie in Dumfries-shire, about three miles from the Solway frith. The same class of rocks reaches from Langholm to Minihive, and at length terminates near New Galloway, where it is succeeded by primitive rocks. The Moorfoot hills near Edinburgh, which form one of the boundaries of the great coal field of the Lothians, are composed of transition rocks; and I have every reason to believe that these rocks continue nearly to the termination of the mountain range at St. Abb's head on the east coast. Granite is said to have been found at Fassnet burn, which is in the tract I consider

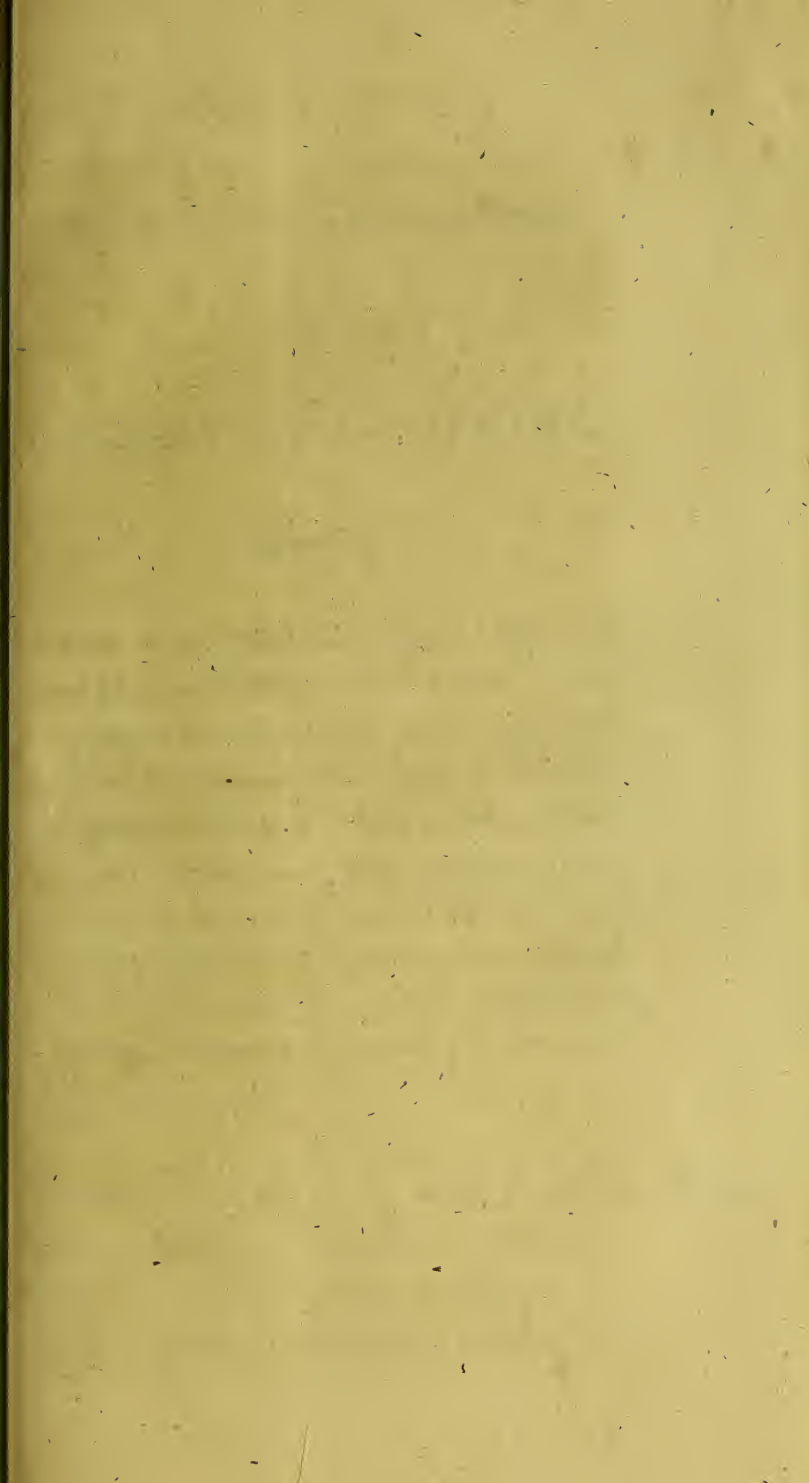
2. With a lead glance formation different from any described by Werner or any other geognost. 3. With a formation of pitchstone, resembling that of the island of Arran, which belongs to the newest floetz-trap formation. 4. With a coal formation which resembles in many respects the old red sandstone, but which is most distinctly different as a formation. 5. With the occurrence of glance coal in the independent coal formation, and with a new subspecies called *columnar glance coal*.

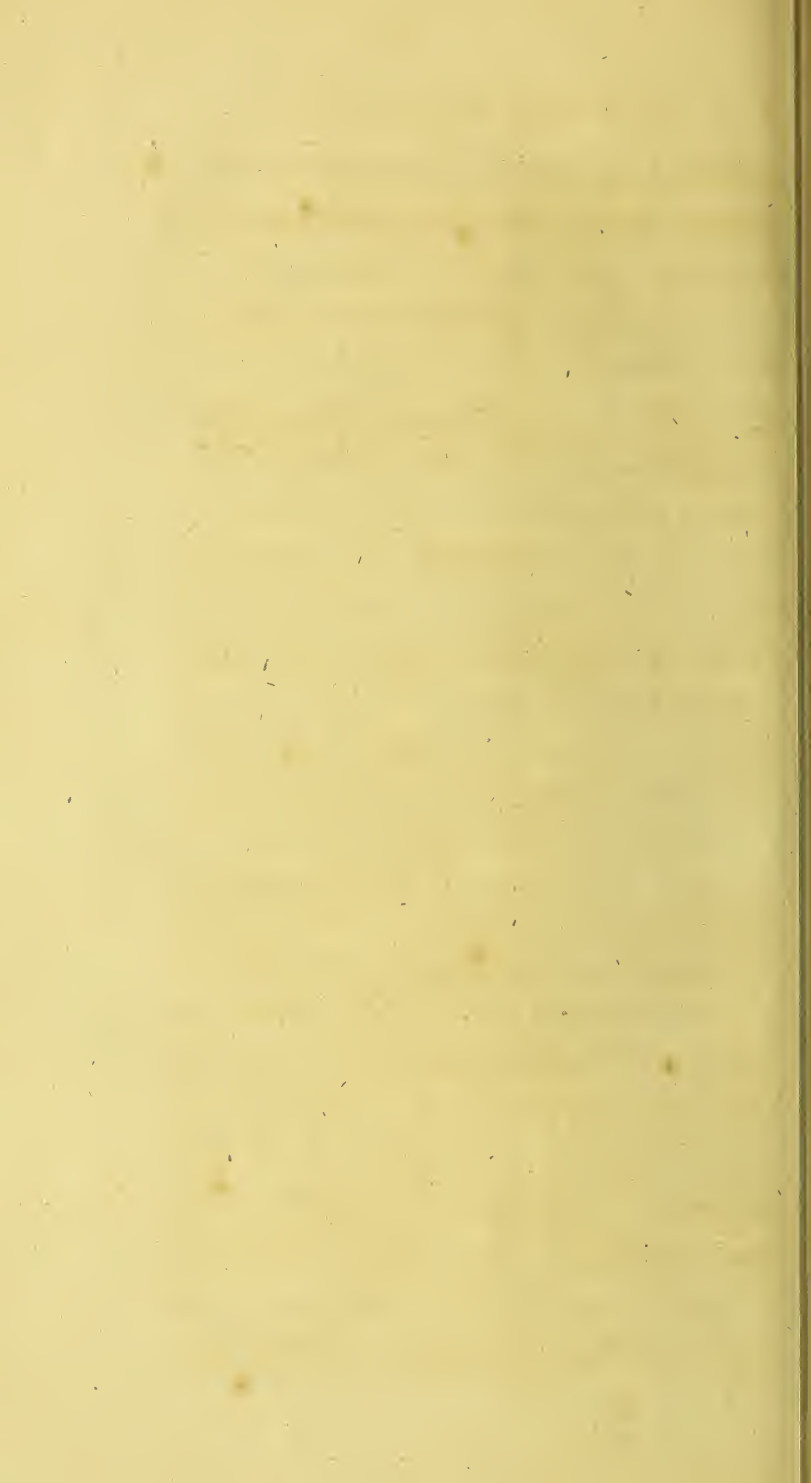
In the Notes and Illustrations there is a particular account of the occurrence of

to be transition. I suppose syenitic greenstone has been confounded with granite.

Since writing the above, I have examined a suite of specimens brought from Fassnet burn and the neighbourhood of St. Abb's head by Dr. Hope, and find my conjecture, respecting the extent of the transition rocks, and the nature of the supposed granite of Fassnet, confirmed.

greenstone in the independent coal formation, a discovery which supplies a link hitherto wanting in the Wernerian trap formation suite, and which shews that there is floetz-trap of different ages ; and with a new graphite formation which differs from that hitherto known in its accompanying fossils and rocks, and in its geognostic situation.





MINERALOGICAL DESCRIPTION

OF THE

COUNTY OF DUMFRIES.

Situation of the County—its Extent—Mountains—Valleys and Rivers.—Observations on the Formation of Valleys—and of the Phenomena presented by those in the County of Dumfries.—Springs.—Those of Moffat.—their Properties and Medicinal virtues.—Springs of salt Water.—Method of determining true salt Springs.—Conjectures respecting the Mineral Impregnations of Springs.—Of the frequency of Springs in Rocks belonging to the floetz-trap Formation.—Lakes.

DUMFRIES-SHIRE is the most southern border county of Scotland. It is bounded on the north by the counties of Larnark, Peebles, and Selkirk; on the west

Situation.

by Kirkcudbrightshire and part of Ayrshire; on the south by the Solway frith; and on the east by the shire of Roxburgh and a part of Cumberland.

Where it is bounded by the shires of Kirkcudbright and Ayr it is mountainous, and equally so where it borders on those of Lanark, Selkirk, and Roxburgh; but on the shores of the Solway frith it is low and comparatively flat.

Extent. It is about fifty miles long, and thirty miles broad.

Mountains. The south of Scotland, according to General Roy, is traversed by a chain of mountains which reaches from Galloway to the east coast of England, including the Cheviot hills. A considerable portion of the upper part of this county is situated in this *chain of mountain groupes* *. The mountainous part of

* See Note A, at the end of this Part.

the county, however, cannot be considered as a part of one groupe, nor as a single groupe, but as composed of several groupes and parts of others, whose opposite declivities fall into the adjoining counties. The determination of the length, breadth, height and shape of these groupes, and of their connections with each other, and with the great southern chain, is an investigation which would prove of much utility to the geographer and to the geognost. I regret that I have not been able, from want of leisure, to satisfy myself respecting this important part of a geognostic investigation; at present I must therefore rest satisfied with stating a very few observations on the chains, and individual mountains of which these chains are composed. I hope, however, that my brother, who is now resident in the county, will execute this very useful piece of investigation.

Characters of
the mountain
chains and
mountains.

The individual chains of which the groupes are composed have generally a narrow foot, a great acclivity, and a round-backed ridge or summit. The mountains of which these chains are composed have in general an inconsiderable foot, a great acclivity, and a very short summit. The summit is generally round-backed or flattened; sometimes it is rather conical, and in a few instances tabular; but in this county the frequent conical and alpine peaked summits are not to be observed; in this respect it forms a striking contrast with the mountainous country to the north of the firth of Forth *.

From the groupes of which the more elevated parts of the county are composed there proceeds a mountain arm that divides part of Annandale from the lower part of Nithsdale, or from that part of it which may be called the valley of Dum-

* Note B.

fries ; and an elevated mountainous country divides the valley of Annan from the valley of Elk.

The highest mountain in the county is ^{Heights of} Hartfell, which was measured by the late Dr Walker ; a number of others have been measured, and their heights are mentioned in the county map, from which the following list is extracted.

NITHSDALE.			Feet above the level of the sea.
Wardlaw in Carlaverock	-		326
Queenberry Hill	-	-	2140
Cairn Kinnow, near Drumlanrig			2080
Black Larg, next Ayrshire	-		2890
Towns of Wanlockhead and Lead-			
hills	-	-	1564
Lowther, near Leadhills	-		3130
ANNANDALE.			
Annan Hill	-	-	256
Repentance Tower	-	-	350
Burnfwork Hill	-	-	740
Errickstane Braehead	-	-	1118
Loch Skene	-	-	1300
Hartfell, above the sea	-		3300

ESKDALE.

Langholm Hill	-	-	1204
Tennis Hill, in Tarres		-	1346
Mossipaul, in Ewes	-	-	820
Wisp Hill, in Ewes	-	-	1836
Ettrick Pen, in Eskdale Moor			2220

Low coun-
try.

That part of the county which lies to the south of what is strictly to be considered the termination of the valleys of Annan and Esk, or of a line drawn from Whinnyrig, by Ecclefechan, Craigshaws, Solway bank, Broomholm and Muirburnhead is comparatively low and flat, and occasionally marked by gently rising round-backed low hills, which sometimes approach to the obtuse conical, as Repentance and Woodcock-air.

The county is divided into three river
Dales. districts *, named Nithsdale, Annandale,
Rivers. and Eskdale, which are traversed by the ri-
vers Nith, Annan, and Esk, that carry

* Note C.

nearly all the water which falls on the surface of the county to the Solway firth.

The river Nith, which rises in the upper part of Ayrshire, enters Nithsdale by the foot of Carsoncone hill, and is poured into a rather circular valley, which is occupied by the parishes of Kirkconnel and Sanquhar. This valley is surrounded by hills, excepting at its upper part, where the Nith enters from Ayrshire, and at its lower part, near Elliock-bridge, where there is a passage through which the river forces its way. The river, after having traversed the valley and collected all the water of this district, continues its course through the passage above mentioned, and winds among hills, until it enters into a nearly similar valley, in which is situated the parishes of Morton, Clofeburn, and part of the parishes of Penpont, Tyrone and Kier. This valley is about seven miles long and two broad, and is surrounded by hills, which in some places are of considerable height. Like the val-

River Nith.

Valley of
Sanquhar.

Valley of
Clofeburn.

Valley of
Dumfries.

ley of Sanquhar and Kirkconnel, it is intersected at its lowest point by the river Nith, which continues its course from this, through a hilly country, and in a rocky channel, until it enters the valley of Dumfries, through which it runs placidly until it pours the collected water of the district of Annandale into the Solway frith, near to Carlaverock castle. This valley differs from the preceding, in being completely open at its southern or lower extremity, where it is bounded by the shores of the Solway frith, and in having a lengthened in place of a circular shape. On its west side it is bounded by the mountains of Galloway, of which the highest is the Criffle: on the east side it is bounded by a mountain arm which separates it from the neighbouring district of Annandale. Through the valley there runs a small hilly ridge, which rises at Carlaverock Castle and terminates at the town of Dumfries, and separates the stream called the Lochar from the Nith. Besides the valleys already mentioned,

there are a number of lateral valleys that open into Nithsdale; of these the most considerable are Crawick, Yochan, Mennoch, Carron, and Skarr. Lateral valleys of Nithsdale.

The valley of Annan, commences above the village of Moffat, in the tremendous hollow of Erickstæne, and terminates near the Manse of St Mungo, a distance of twenty-three miles. Several lateral valleys terminate in it; of these the most considerable are Moffat and Dryffe; Lateral Valleys of Annan. others of less importance are Kennel, Dryffe, &c. Whamphry, and Evan. Besides the valley of Annan and the lateral valleys that open into it, there is another valley in the district of Annandale, which opens without the valley of Annan. It is called the valley of Milk. It takes its rise from the mountains called Milk Water-head, which are situated in the high country that separates Annandale from Eskdale, and terminates at Sorryfyke, a little way above the confluence of the water of Milk with the river Annan. Valley of Milk. Ex-

terior valleys of less importance are Mein and Kirtle.

River Annan.

The river Annan rises in the high mountains above Moffat *, and runs through the flat part of the valley of Annan (principally through alluvial land) until near the manse of Saint Mungo, where it flows between and over rocks of the floetz-trap formation. From this point, which, as it is the termination, is also the lowest point of the valley of Annan, it continues its course through the lower part of the district of Annandale, and after a run of thirty-seven miles from its source, it is poured into the Solway frith at Annan.

Valley of
Esk.

This valley commences from the mountains called Esk Water-head, and continues bounded by high hills to Broomholm, about four miles below Langholm ; from

* From the north-west side of these mountains the river Clyde rises, and from the north-east the river Tweed ; a proof that they are the most elevated points in the south of Scotland.

this until its termination in the Solway frith it proceeds through a flat country, and is rather to be viewed as a deep river-course than as a valley. Several lateral valleys open into it, and of these the most considerable are Black Esk, Meggot, Ewes, and Wauchope. Lateral valleys of Esk.

The river Esk rises in the high country of Esk Water-head, and runs among mountains to Broomholm, in its course being joined by the streams of Black Esk, Meggot, Ewes, and Wauchope. From Broomholm it flows through a flat country, and before it reaches the Solway frith it passes through a corner of Cumberland, and is joined by the river Liddel from Roxburghshire and the Line of Cumberland. Its length is thirty miles in the county of Dumfries, but thirty-eight to the Solway frith. River Esk,

The sides of the valleys are in general smooth and covered with vegetation; sometimes they are rocky and cliffy. Character of the sides of the valleys.

Bottom of
the valleys.

The bottoms of the valleys are sometimes rocky, but more generally covered by alluvial or water-borne land. On the lowest banks of the rivers, where the newest alluvial land is deposited, there is found the richest and most productive tracts in Dumfries-shire.

The nearly inclosed valleys of Sanquhar and Kirkconnel, and of Closeburn and Annan are phenomena deserving of our particular attention, from the information they convey to us, not only of the former state of the earth's surface, but of the changes which it has still to undergo. I shall employ this opportunity of mentioning several remarkable appearances of a similar kind, which have been observed in this and in other countries, with the view of directing the attention of geognosts to phenomena which are in many respects highly interesting, and of rendering the explanation which I shall attempt to give of the formation of the valleys in Dumfries-shire more distinct.

The river Don in Aberdeenshire, according to the description given by Dr Anderson, in his Agricultural Report of that county, passes through several circular or nearly inclosed valleys. “The Don,” he observes, “assumes a character in every respect the reverse of the Dee; at its mouth its rocks confine it to a narrow channel, and give to it there a gloomy aspect, which would convey the idea of its flowing through a mountainous and rugged country, where no space was left for forming even a commodious road along its banks; but on ascending on it for about one mile, the hills recede from it, so as to form spacious haughs on either side, through which the river flows in a slow and majestic course for many miles; nor is the prospect here uniform, but agreeably diversified, the hills above Inverury approaching close to the river, through which it seems to have forced its way with difficulty, then all at once it opens

Valleys on the river Don.

“ into another spacious plain, from which
 “ they recede on either hand to a great
 “ distance, then it closes again ; and, after
 “ another temporary confinement among
 “ rocks and hills and woods, it waters
 “ once more another plain of great extent.
 “ Such is the general character of this
 “ river.” The Rhone, in its course to
 the sea, also passes through several valleys
 resembling those of the Don, Nith, and
 Annan. The Rhine also passes through
 similar basins or valleys during its pro-
 gress towards the ocean.

Valleys on
the Rhone
and Rhine.

The Danube, whose history has been
 so well illustrated by the Count de Mar-
 figli, has its source in the mountains of
 Swabia, from whence it passes through
 Swabia, Bavaria, Austria, Hungary, and
 Wallachia, into the Black sea. Swabia is a
 great circular valley, from which the
 Danube escapes by a narrow rocky open-
 ing into Bavaria ; during its progress
 through Bavaria it passes through several

Valleys on
the Danube.

circular valleys into Lower Austria, which is also a circular valley. It flows through Austria, and at Presburg, where the valley is nearly shut up, it forces its way through rocks and hills into Hungary, which is one of the most extensive circular valleys in Europe. At the lower extremity of Hungary the river is again forced to seek its way through a narrow rocky channel at Orosova, which is the only opening between Hungary and Wallachia. It now continues its course through Wallachia, and at length falls into the Black sea. We have a continuation of this chain of valleys, although still filled with water, in the Black sea, sea of Marmora, and the Mediteranean *,

Mr Pennant, in the first volume of his ^{Valley of} Outlines of the Globe, when describing ^{Cachmere,} the country of Cachmere, observes, " This
 " happy valley, this paradise of Hin-
 " dostan, of the Indian poets, is of an

* Note D.

“ oval form, about eighty miles long and
 “ forty broad, and was once supposed to
 “ have been entirely filled with water,
 “ which, having burst its mound, left the
 “ vale nourished to the most distant ages
 “ by the fertilizing mud of the river which
 “ fed its expanse. This delicious spot
 “ is surrounded by mountains of vast
 “ height and rude aspect, covered with
 “ snow and incased in glaciers, in which
 “ this enchanting jewel is firmly set.”

Valleys on
the Elbe.

Bohemia is a great circular valley,
 whose bottom inclines towards its only
 opening above Königstein, through which
 issues the river Elbe, carrying with it all
 the water that falls in Bohemia. Imme-
 diately below this narrow rocky outlet
 there is another small circular valley,
 which extends from Königstein to Pirna;
 at Pirna it is nearly closed up, the river
 forcing its way through a narrow rocky
 opening, and at length it issues into a
 very beautiful circular valley in which
 the delightful city of Dresden is situated.

This valley, as we approach Meissen, becomes narrow, and the river Elbe again flows through a rocky channel until it escapes into the low country, through which it winds and traverses the flats of Lower Saxony, and at length is poured into the North sea at Cuxhaven.

Having now briefly mentioned some of the most remarkable instances of circular or inclosed valleys, which have been observed by geographers, I shall add a few observations on the formation of valleys, and shall then hazard a conjecture respecting the formation of the valleys of Sanquhar, Closeburn, and Annan.

Many different explanations have been proposed respecting the formation of valleys, but the opinion which has been most generally adopted, is that which asserts that all valleys have been hollowed out of the solid rock by the action of running water. The following observations contain what some will consider to

Opinions respecting the formation of valleys.

be the most probable explanation of these interesting phenomena.

Valleys formed by mountain groupes.

1. Chains of mountain groupes are sometimes disposed in a circular form, so as to include great tracts of flat country, as is the case with Swabia, Hungary, Transilvania, &c. These circular valleys are therefore evidently not the effects of running water.

Valleys formed by original inequalities.

2. *a.* Granite, the oldest rock with which we are acquainted*, has been formed with great inequalities, and these have given rise to many of the valleys that now mark the surface of the earth. Although many of these original inequalities have been filled up by the deposition of newer rocks as gneiss, mica slate, clay slate, &c. yet many have remained in their original state, or have been but partially filled, so that in either case there still remained

* The opinion that granite is one of the newer rocks has been refuted in Nicholson's Journal.

very great inequalities, not formed by the action of running water.

b. In many instances the newer rocks, as gneifs, mica slate, and clay slate, after filling up the granite hollows, appear to have been deposited in greater quantity in one place than another, and thus original inequalities, or mountains and valleys have been formed.

3. It is not improbable, from what we know of the natural history of rents, that in many cases, particularly in the higher parts of the globe, immense fissures may have been formed, and these by the long continued action of water may have been fashioned out into valleys*.

Valleys formed by the widening of great rents.

4. Neither is it to be doubted that running water has frequently hollowed valleys out of a surface not very deeply

Valleys formed by the action of running water.

* Werner neue Theorie von der Entstehung der Gänge, f. 253.

marked by original inequalities, and that it has also, during a long course of ages, enlarged and deepened the original valleys.

We have thus valleys formed by the original grouping of primitive mountains, by the inequalities of the oldest rocks, by the widening of great rents, and by the action of running water. Having thus shewn how it is probable that many of these concavities have been produced, let us view the surface of the earth as it appeared on the retiring of the ocean, which formerly covered it to a great height*.

Appearance
of the earth
on the retir-
ing of the
ocean.

As the original ocean gradually diminished and left the land uncovered, those concavities which had no outlet would be left filled with water, and thus lakes would be formed; other inequalities

* In the third volume of my System of Mineralogy will be found Werner's demonstration of the important fact that the ocean formerly covered the whole globe.

would, by collecting the waters precipitated on their surface, form the mighty original rivers. During the course of ages these original lakes and great rivers would, by the action of natural causes, gradually alter the earth's surface; lakes, by evaporation, or by their finding an exit by subterranean canals would become dry, and thus we would have in their stead rich valleys surrounded by mountains. In South America we have striking instances of valleys of this kind, and also, but on a smaller scale, in Europe. Other lakes, and this appears to be the most common mode of change, by the deepening of their outlets and the filling up of their bottoms with gravel, &c. would at length disappear, and what was formerly a great lake would be changed into a valley, having a river traversing its bottom, and issuing by a narrow opening into the lower country. Others, according to Werner, appear to have opened to themselves a passage in a very violent and sudden manner.

Different
ages of val-
leys.

But all these valleys are not of equal antiquity. After the water had diminished to a pretty low level, it appears to have risen again, to have covered the then existing system of inequalities, and to have deposited over the surface of the earth a mighty and universal formation (the floetz-trap formation). What were formerly longitudinal valleys, through which great rivers flowed uninterrupted to the sea, were in many instances changed into inland seas or lakes, by the deposition of the newer formation across their communication with the ocean, others were entirely filled up, and thus on the retiring of the waters of the ocean, a nearly new system of rivers and lakes and valleys made its appearance. The facts on which this opinion of the different ages of valleys is founded are numerous and conclusive, but cannot be detailed here.

Valley of
Sanquhar
formerly a
lake.

The valley of Sanquhar and Kirkconnel appears to have been formerly in the state of a lake, because it is entirely fur-

rounded by mountains, excepting at its communication with the valley of Closeburn, (which communication has been effected by the action of the lake emptying itself, and that of the river), and at Carfonconne-hill, where it borders on Ayrshire. The valley of Closeburn has been formerly in a similar state.

Valley of
Closeburn
formerly a
lake.

The valley of Annan, however, was probably at a former period a hollow in the transition rocks in which a great river flowed, (vastly greater than that which now exists), but by the deposition of floetz-trap rocks across its communication with the ocean, it appears afterwards to have been converted into an inland sea or lake*. The water of the lake, after the retiring of the ocean,

Valley of
Annan at one
period a wa-
ter course of
a great river.

Afterwards a
lake, and a-
gain a water-
course of a
river.

* To those acquainted with the geognostic relations and history of the transition and floetz-trap rocks, the description of the relative position of the rocks of this valley, contained in Chapter 2d, will render any further explanation of the above mentioned opinion unnecessary.

The river is gradually diminishing.

appears to have worn a passage through the opposing rocks, and at length, as Professor Playfair well expresses it, it has passed from the state of a lake to that of a river. The river has gradually deepened its channel, and is diminished in height and breadth. That the river formerly stood at a greater height, and possessed greater breadth than it does at present, is shewn by the great height of the original or high banks and their distance from one another.

SPRINGS.

The only springs deserving of attention in this county are those near the village of Moffat, which have been long well known on account of their medicinal virtues*.

* There is a chalybeate spring at Brow, in the parish of Ruthwell.

There are three springs, a sulphureous, and two chalybeate.

The sulphureous spring, or, as it is Moffat well. called, Moffat well, is about a mile and a half from the village of Moffat. It oozes out of a rock of compact grey wacke, which contains interspersed iron pyrites. At a little distance there is a bog, which along with the pyrites in the grey wacke, probably afford the sulphureous impregnation to the spring. The water has a strong sulphureous smell, resembling that of the sulphureous waters of Harrowgate, but not quite so strong. It has a slight saline taste, and sparkles when first taken from the spring, particularly when poured out of one glass into another. The sides of the well are covered with a yellowish grey crust of sulphur, and when the water has been allowed to stand some days without pumping, it becomes covered with a yellowish white film of sulphur. According to the analysis of the late Dr

Qualities.

Garnet, a wine gallon of this spring contains,

Constituent parts.	Of muriat of soda (common salt)	36 grains
	Sulphurated hydrogen gas	10 cubic inches
	Azotic gas	4 do.
	Carbonic acid	5 do.*

The water will not keep, however closely it is corked up, the sulphurated hydrogen escaping; it should therefore be used as soon as possible after it is taken from the well.

The water of this spring is much used in scorbutic and scrophulous cases; and, it is said, in certain stages of these diseases, with good effect †.

Hartfell
spaw.

The most considerable chalybeate spring, which is called Hartfell spaw, issues from a rock of alum slate, in a tremendous ravine on the side of the

* Garnet's Tour in Scotland, vol. 2.

† Dr. Johnstone, in Garnet's Tour.

mountain of Hartfell, nearly five miles distant from the village of Moffat. Among the strata of alum slate in this ravine, I observed frequently efflorescences of yellowish grey coloured natural alum; and Dr. Garnet mentions that he found crystals of natural iron vitriol. In the alum slate I observed massive and disseminated iron pyrites.

Dr. Garnet found that a wine gallon of Hartfell spaw contained

Constituent
parts.

Of Sulphat of iron (iron vitriol)	84 grains
Sulphat of alumina	42 do.
Azotic gas	5 cubic inches.

Together with fifteen grains of oxide of iron, with which the sulphuric acid seems to be supersaturated, and which it gradually deposits on exposure to the air, and almost immediately when boiled. The water of this spring, after heavy and continued rains, is always increased in quantity and strength. This latter cir-

cumstance is owing to the atmospheric water, during heavy rains, passing through channels in the alum rock more richly impregnated with the materials of the spring than those it passes through during a long continued drought.

Dr. Garnet observes, “ as the principal mineralizers of this water are the sulphats of iron and alumina, it is evident that, if well corked, it will keep for months, and perhaps years, unimpaired in its qualities ; hence it may be carried to a distance better than most mineral waters. As it keeps so well it is not necessary to drink it on the spot, which would be very inconvenient, but it may be procured in Moffat in a fresh state.”

The Hartfell spaw, being a very powerful tonic, is useful in diseases of weakness. Dr. Johnstone remarks, “ I have likewise known many instances of its particular good effects in coughs proceeding from phlegm, spitting of blood,

" and sweatings ; in stomach complaints
 " attended with headaches, giddiness,
 " heartburn, vomiting, indigestion, flatu-
 " lency, and habitual costiveness ; in
 " gouty complaints affecting the stomach
 " and bowels ; and in diseases peculiar
 " to the fair sex. It has likewise been
 " used with great advantage in tetterous
 " complaints, and old obstinate ulcers *."

The other chalybeate spring, which ^{Chalybeate}
 was discovered by Dr. Garnet, is near ^{spring at} Evan bridge.
 Evan bridge. He found it to contain in
 the wine gallon

Oxide of iron	2 grains
Carbonic acid	13 cubic inches
Azotic gas	2 do.

The quantities of iron and carbonic
 acid, which are the only substances of
 any consequence, are very nearly equal
 to those in the chalybeate of Harrowgate.

From this circumstance it cannot be doubted, that if this well were properly inclosed it would be a valuable addition to Moffat. It would agree with many constitutions in which the Hartfell water is improper, on account of its too great astringency and tonic power; and its vicinity to Moffat is a great advantage, as it can be drank on the spot by those who resort to the watering place *. On enquiry I found that no attention had been paid to this spring, which is probably to be regretted.

Springs of
salt water.

I observed on the banks of the Solway frith small springs, pouring out salt water, issuing from rocks belonging to the coal formation. These, however, evidently derived their water from the frith, and are not to be confounded with true salt springs, which are only found in that series of rock which is interposed between the newest transition and the fe-

* Garnet's Tour.

cond sandstone formation, or in countries bordering on it. To determine whether or not a salt spring found on the sea shore derives its contents from sea water, or from a salt-bed or rock richly impregnated with salt, a chemical examination is not sufficient, because it often happens that salt springs, issuing from salt-beds, and not richer in salt than sea water, are poured out on the sea shore. To determine such a point, therefore, we must examine the neighbouring country, with the view of discovering whether or not similar springs occur inland, or if there is any appearance of the series of rock already mentioned; if we discover these, we may then with complete safety conclude that the salt springs we have discovered are derived from salt-beds, or rocks richly impregnated with salt, and are therefore worthy of particular attention, although a chemical analysis should have shewn that they were not more productive than the waters of the ocean.

Method of
determining
true salt
springs.

Sources of
mineral im-
pregnations
of springs.

Observations.—All springs derive their water from the atmosphere, and their impregnations in most cases from the rocks through which they pass. Thus the numerous salt springs in Cheshire, Salzburg, &c. can be traced to salt-beds or rocks highly impregnated with salt; calcareous springs to beds of limestone; and aluminous springs, like that of Hartfell, to rocks containing alum or its ingredients. The constant occurrence, however, of sea salt in all springs, is more difficultly accounted for. Sea salt, or muriat of soda, has been discovered in white ore of antimony, which occurs venigenous in mica slate, in horn ore, which is found in gneiss, in certain varieties of lead ore, and in one species of copper ore. These are, however, but partial occurrences in comparison of the universality of the phenomenon here alluded to. The Wernerian geognosie teaches that, even during the deposition of the transition rocks, marine animals and plants existed; consequently the sea must have

been in a state somewhat similar to what it is at present, consequently must have contained sea salt. We have therefore reason to expect that all these rocks contain sea salt, and that this impregnation affords to the filtrating water of springs the sea salt they are always found to contain.

Sea salt of springs derived from the rocks through which the water filtrates.

The analyses of an able chemist, the late Dr. Kennedy, have shewn the presence of soda and muriatic acid in basalt, greenstone, and sandstone; and more lately the celebrated Klaproth has obtained from basalt, porphyry slate, and pitchstone similar results. As these rocks belong to one of the *universal formations*, these analyses are to be viewed as supporting the conclusion drawn from the Wernerian geognosie.

2. Dr. Garnet does not mention soda as a constituent part of the springs at Moffat; it is not improbable, however, that it may be discovered on a more care-

Soda probably a constituent part of the Moffat well spring.

ful examination because almost all the springs issuing from transition rocks that have been examined have been found to contain a minute portion. As an instance, I may mention that the Graf Mitrowsky analysed twenty springs issuing from the transition rocks of the circle of Olmutz in Moravia, and found that all of them contained a greater or lesser proportion of soda.

Frequency of
springs in
floetz-trap
rocks.

3. A greater number of springs issue from rocks belonging to the floetz-trap formation, than from those of the transition or coal formations. In other parts of Scotland, particularly in the mountains of the isle of Rume, I made a similar remark. Werner observes that basaltic hills are well calculated, by reason of their naked surfaces and compact texture to attract and condense vapour, and from their numerous perpendicular rents, and the bed of clay on which they usually rest, to conduct the condensed vapour to form springs.

LAKES.

There are very few lakes in this county. In the neighbourhood of Lochmaben there are five, one on the north east corner of the county called Loch Skene, another on the west side called Loch Urr, but none of them are remarkable for magnitude or beauty, nor do they present any phenomena deserving particular notice.

CHAP. II.

Plan to be followed in describing the internal Structure of the County.—1. General Disposition of the Stratification.—2. General Disposition of the Formations.—3. More particular Account of the different Formations.—a. Of the Transition Rocks.—b. Of the independent Coal Formation.—c. Of the Floetz-trap Formation.—d. Of the Alluvial Formations.—Of Peat.

HAVING described the mountains and valleys which, taken together, constitute the physiognomy of the county, I shall now proceed to give an account, as far as observation permits me, of its internal structure. Here we have 1st to ascertain the general disposition of the stratification. 2dly, That of the individual formations; and, 3dly, we must give a particular account of the formations and of the rocks of which these formations are composed.

I.

One of the most important relations which mountain groupes present us with, when viewing them on the great scale, is the general disposition of their stratification; to discover which, therefore, is an object of the greatest importance to the geognost. If we confine our observations to one rock mass, it is sufficient to say whether it is in conformable or unconformable stratification; its direction and dip are of very little importance if we do not extend our observations further. On the contrary, if our observations are to be more general, and if we wish to discover the general stretch and dip of the strata of an extensive district, we must make a number of individual and accurate observations, and from the sum of these determine the general disposition of the stratification. The general disposition itself, however, has sometimes its variations, and these must be noted and at-

tended to. An acquaintance with the shape of a mountain groupe will assist us very much in such investigations, as it is intimately connected with the general disposition of the stratification of the masses of which it is composed. It is also of importance to know the fall or declivity of a groupe, as its direction and inclination is generally conformable, particularly in the older formations, with that of the superimposed masses. Sometimes indeed there are exceptions to this rule, but these are easily explained.

I have to regret, however, that my observations have not as yet been sufficiently numerous to enable me to state with confidence the general disposition of the stratification. According to my present observations, the general direction of the strata appears to be from east to west, and their dip to the south, under various angles, but more generally very much inclined, particularly the transition rocks.

II.

Nearly the whole of the upper part of this county is composed of transition rocks. It does not, however, present all the species of rocks that occur in this great class in other parts of the world; I have observed only *grey-wacke*, *grey-wacke slate*, *flinty slate*, *alum slate*, and *transition greenstone*. General disposition of the formations.

The grey-wacke forms a very great portion of the upper part of the county, and sometimes alternates with grey-wacke slate.

The flinty slate occurs in small quantity; but on the borders of the county, at Leadhills, there are great beds of it.

Greenstone occurs in beds in grey-wacke and grey-wacke slate, as between Whamphry and Langholm, and on the borders of the county, in the valley of Leadhills.

Alum slate occurs near Moffat and Kirkmichael.

These rocks are the oldest in the county, and consequently serve as a basis for all the newer formations.*

The next class of rocks in point of age and extent is the *independent coal formation*, which lies either in hollows of the transition rocks, as the case is at Sanquhar, Kirkconnel, Closeburn, valley of Dumfries, Whitehill, Corncocke muir, Bauldcraig, and Chapelhill near Moffat, Cannoby, or pervades the low part of the county from the Esk to the Nith, lying in conformable and unconformable stratification over the transition rocks.

The newest of the *universal formations* is the newest floetz-trap, which covers sometimes the transition rocks, and sometimes the independent coal formation.

* Note E.

In the lower parts of the county it consists of porphyritic greenstone, and amygdaloid, which extends from the bridge of Langholm to Denby in the parish of Dalton. In the upper part of the county, as between Whamphry and Langholm, it lies on the summit of transition mountains, and generally in the shape of *mountain caps*. Subordinate to it we find blackish coloured pitchstone.

The bottoms of the valleys are covered by the alluvial formations.

III.

Having now given a description of the physiognomy of the county, of the general disposition of its stratification, and the relative age and situation of its different formations, and thus drawn as it were an outline of its geognostic description, I shall now endeavour, as far as my obser-

More particular account of the different formations.

vations will allow, to render it more complete. To execute this in a satisfactory manner, many more observations are required than I have had an opportunity of making ; I shall, however, first state how the investigation should be conducted, and then the observations I have made.

Plan that should be followed in giving a particular account of the formations.

To execute such an investigation we must trace correctly the bounds of all the formations; then delineate the most striking features in the disposition of their stratification; next must describe their different strata and beds, and lastly the individual rocks. But in doing this, we must adopt a determinate order, we must not begin indifferently with any formation, but should adhere to the order which nature appears to have followed in their deposition, that is, according to their relative antiquity, proceeding from the oldest to the newest. But it is not enough that we have attended to all the circumstances I have just mentioned, our

descriptions of the formations would be imperfect if we omitted an account of the *particular repositories*, as veins, stockworks, &c. contained in them. In general, however, if these repositories are of *after formation*, and occur in considerable number, it would be better to separate the account of them from the description of the rocks, and place it in a separate chapter, as the introduction of such descriptions distracts the attention, and prevents us obtaining a correct idea of the more general relations of the rocks. In describing these *after repositories*, however, we must follow a determinate plan, as much so as in describing the rocks. When we have not had repeated opportunities of determining the relative age, the peculiar characters, and the structure of these different repositories, the most convenient plan of arrangement would be, that according to the age of the rock in which they are found; if, however, we have ascertained these points, the natural arrangement is that according to

their relative antiquity. In conformity with the method now mentioned, I shall first give an account of the

Transition
rocks,

A. TRANSITION ROCKS.

First discovered and ascertained to be a distinct class by Werner.

The transition rocks were formerly confounded with the primitive, until Werner by an attentive examination found that they contained mechanical deposits, petrifications, and, considered as a class, were more simple than the primitive. He also discovered that they were formed during the transition of the earth from its chaotic to its habitable state, hence he denominated them *übergangsgesteine*, *transition rocks*. This very important discovery has been confirmed by every succeeding observation, and the distinction here proposed has been adopted by all geognosts *.

* The objections of Professor Playfair, are answered in Nicholson's Journal.

The rocks belonging to this class are, according to Werner, 1. Grey-wacke, 2. Grey-wacke slate, or transition slate. 3. Transition limestone, 4. Transition greenstone. 5. Transition amygdaloid. And, 6. Flinty slate. Of these species, as already mentioned, four only have as yet been observed in this county, viz. Grey-wacke, grey-wacke slate, transition greenstone, and flinty slate. The alum slate already mentioned may be considered subordinate to the transition slate.

1. *Grey-wacke*. Is composed of frag- Grey-wacke. ments of quartz and clay slate, which are from the size of a hen's egg, until from their minuteness, they are no longer visible. The fragments are connected by a basis of clay slate, which has usually a bluish grey or brownish colour. It is often traversed by nearly cotemporaneous quartz veins; and, as Werner observes, the quartz solution appears often to have disseminated itself through it, which renders this rock so firm and hard. It fre-

quently also contains scales of mica, particularly when it approaches in characters to transition slate. The clay slate basis distinguishes it from sand stone, and from its usual grey colour, it derived its name,

Its texture is to be observed becoming gradually fine grained, and verging on slaty; at length the eye can no longer distinguish any mechanical mixture, the slaty texture becomes more complete, and then it passes into

Grey-wacke
slate.

2. *Transition, or grey-wacke slate.* This rock has been very generally confounded with primitive clay slate; from which, however, it is very well distinguished by the following characters.

How distinguished from
clay, or primitive slate.

a. It has seldom a greenish or light yellowish grey colour, as is the case with primitive slate, but is usually ash and smoke grey.

b. It does not show the silvery continuous lustre of primitive clay slate, but is rather glimmering, which originates from intermixed scales of mica.

c. Quartz scarcely occurs in it in layers, but usually traverses it in the form of veins.

Further we do not find.

d. Crystals of felspar, schorl, tourmaline, garnet or hornblende.

e. No beds of garnet, talc, chlorite slate, or magnetic iron stone are to be observed in it.

f. It contains petrifications, particularly those varieties that border on greywacke.*

* The petrifications found in transition rocks, are of animals and plants of the lower orders, that probably no longer exist on the face of the earth.

g. It alternates with grey-wacke.

This slate, when nearly free of mechanical mixture, is excellently adapted for the roofing of houses. Near Moffat, and in the vicinity of Langholm, there are workable strata of grey-wacke slate, and in the higher parts of the valley of Esk, and in the transition rocks behind Burnswark, there are appearances of a similar kind. There is no doubt, that a careful examination of the immense tract of transition rocks that occur in this county, will discover strata of slate worthy of particular attention. My brother has promised to examine these rocks with this view.

Flinty slate.

3. *Flinty slate.* This fossil presents the following characters.

Colour is bluish grey.

Occurs massive, and in great beds.

Internally dull.

Fracture in the great imperfectly flaty, in the small large splintery, passing into flat conchoidal.

Fragments indeterminately angular,
pretty sharp edged.

Strongly translucent on the edges.

Hard.

Brittle.

Difficultly frangible.

Not particularly heavy.

It is frequently intermixed with transition clay slate.

4. *Common alum slate.*

Common alum slate.

Its colour is greyish black.

Occurs massive.

Internally glimmering, bordering on faintly glistening.

Fracture pretty perfectly straight flaty.

Fragments tabular.

Streak a little shining.

Soft.

Not particularly brittle.

Easily frangible.

Not particularly heavy; that is, from

2 to 4.

H

On exposure to the air, a yellowish sulphureous efflorescence sometimes makes its appearance: natural alum sometimes effloresces on its surface.

Transition
greenstone.

5. *Transition greenstone.* On the hanging or upper side of the Sufanna vein in the valley of Leadhills, I observed a bed of rock which at first I mistook for porphyry, but which proved, on more attentive examination, to be greenstone. It is almost entirely composed of felspar, which has usually a pale flesh red, or reddish white colour: in it there is sometimes imbedded grains of greyish coloured quartz, scales of iron black coloured mica, and crystals of pale flesh coloured felspar. Sometimes the basis is in a state of disintegration, and then it resembles porcelain clay.

It occurs in beds from three to twelve feet thick; and not only in the valley of Leadhills, but also in the mountains between Whamphry and Eskdale muir.

Observations. In hand specimens, this rock would be confounded with porphyry; but considering it in the great, we must, consistent with our present knowledge of porphyry and greenstone, view it as greenstone (in which the hornblende is a wanting) or as felspar. In the floetz formations, as will afterwards be more particularly mentioned, I have observed greenstone almost entirely composed of compact felspar, with a few interspersed crystals of hornblende; yet we would not consider such a rock as a particular species, but merely as a variety of greenstone. In other instances, I have met with beds, in which the hornblende was entirely a wanting; in such cases, we might probably venture to consider it as felspar, and as nearly analogous to the rock of Leadhills; although, in the great, we would view the one and other but as varieties of greenstone, or as subordinate to it.*

This greenstone in hand in specimens might be mistaken for porphyry.

Beds of greenstone almost entirely composed of felspar.

* Note F.

Mineral repositories in the transition rocks.

The only *particular metallic mineral repositories* † of consequence that have been discovered in this country, lye in the transition rocks. They are situated on the borders of the county at Wanlock-head and Leadhills, and lower down at Glendinning in Eskdale.

Belton-grain vein at Wanlock-head.

At Wanlock-head, I descended into one of the mines, into the vein called Belton-grain vein, which was at that time but lately opened. It stretches nearly N. and S., and dips to the E. under an angle of from 60° to 80°. Its width is from six to eight feet.

† Repository.] By the term *particular mineral repository*, which in German is *besondere lagerstätte der fossilien*, and in French *gites particuliers des minerais*, is understood those spaces in rock masses or mountains whose extent, in one direction at least, can be observed, and which in general are occupied with materials different from the rock in which they occur. Under this denomination is included strata, beds, veins, &c.

The following are the appearances presented by the vein, in the different places I had an opportunity of examining. I regret my observations were not sufficiently numerous to enable me to ascertain its general structure and peculiarities, and thus to determine its characters, as a particular deposition or formation.

1. In several places, I observed the whole width of the vein filled with blackish brown coloured ochre of manganese, in which fragments of greywacke, which constituted the walls of the vein, were immersed; in other places, the manganese contained crystals of quartz, and masses of lead glance*, and sometimes drussy cavities, which were lined with calamine and green lead ore.

* I use the term lead glance instead of the more usual one galena, because it is English, and expresses the most striking feature in the external aspect of the mineral.

2. At the north extremity of the first gallery, the structure of the vein was as follows:—On the under, or lying side, lead glance; above it, layers of quartz, then layers of manganese ochre, and brown iron ochre; and lastly, on the upper side, about two feet of debris, mixed with manganese.

3. At another place, at the depth of seventeen fathoms, on the under side of the vein, was a white clayey seam, (besteg.) about an inch thick, above this a layer of ochre of manganese, about eight inches thick; then a layer of green lead ore, intermixed with calamine, about an inch thick; then a layer of lead glance, from four to five inches thick, which contained druses lined with calamine and white lead ore; to this succeeded a layer of granular quartz, from four to five inches thick; on this reposed a layer of lead glance, about eight inches wide, having also drussy cavities; over this there lay another layer of ochre of

manganefe, a few inches thick, which contained interſperſed green copper ore; and laſtly, the upper or hanging ſide of the vein conſiſted, for a foot and half, of fragments of grey-wacke and grey-wacke ſlate, intermixed with ochre of manganefe.

4. In another part of the vein, its ſtructure and materials was as follows: 1ſt, Sides of the vein were lined with a layer a few inches thick of ochre of manganefe. 2d, To this ſucceeded layers of brown ochre of iron. 3d, Thin layers of calamine. 4th, Thin layer of lead glance, which was coarſe, ſmall and fine grained. 5th, Layer of browniſh coloured arenaceous quartz, of which the concretions were ſo looſe that it could be diſintegrated by the hand*; and, 6th, the middle of the vein was filled with manganefe.

* Note G.

Lead hills. Leadhills, which is but a short distance from Wanlock-head, also presents many rich veins of lead glance. Of these the greatest and most productive is the Sufanna vein.

Sufanna vein. This vein stretches nearly in the direction of the valley in which it is situated, and its fall is nearly conformable with that of the mountains. Its usual breadth is about four feet: several years ago it was in one place about fourteen feet wide, but this was owing to a partial enlargement, or what the miners term *a belly*.

Its structure is the same with that of Belton-grain at Wanlock-head, and its materials are nearly identical. The *vein stones** are quartz, lamellar heavy-spar, calc-spar, brown-spar, and mountain cork. Its *ores* are lead glance, man-

* I use the expression vein stones in preference to the term gangue, because it has a determinate meaning.

ganefé ochre, lead earth, sparry iron ore, calamine, brown iron ochre, iron pyrites, copper azure, green lead ore, white lead ore, lead vitriol, and brown hematite.

The vein has sometimes interposed between it and the rock in which it runs a thin seam of clay or loam; sometimes this is wanting, and not unfrequently the matter of the vein is grown together with the rock which forms its sides.

Like the veins of Wanlock-head, it often contains fragments of grey-wacke and grey-wacke slate.

The lead glance formation of Wanlock-head and Leadhills, is completely different from any enumerated and described by Werner, as is evident from the inspection of the following descriptions, extracted from his admirable work on veins. “ We
 “ already know perhaps more than twenty
 “ different formations of lead glance. I
 “ have observed the following :

Lead glance formation of Leadhills and Wanlock different from any enumerated by Werner.

Different
lead glance
formations as
determined
by Werner.

“ 1st *Formation*. Lead glance mixed
“ with copper pyrites and native gold; in
“ quartz.

“ 2d *Formation*. Lead glance, with small
“ grained brown blende, and flate spar.

“ 3d *Formation*. Lead glance rich in
“ silver, with fine grained brown blende,
“ and a little copper and iron pyrites; in
“ quartz.

“ 4th *Formation*. Lead glance rich in
“ silver, with much black blende and
“ arsenical and iron pyrites, sometimes
“ with a little copper pyrites, more rarely
“ with sparry iron ore; in quartz and
“ sometimes accompanied by a little
“ brown spar.

“ 5th *Formation*. Lead glance very rich
“ in silver, with black blende, very little
“ arsenical pyrites, common iron pyrites,
“ and liverp yrites; in quartz and brown
“ spar.

“ 6th *Formation*. Lead glance very
“ rich in silver, with a little black blende,
“ common iron pyrites, dark red silver
“ ore, brittle silver ore, white silver ore,
“ plumose silver ore; in quartz, with
“ much, generally flesh red coloured,
“ brown spar.

“ 7th *Formation*. Lead glance poor in
“ silver, with a great deal of common
“ iron pyrites, black blende, and often
“ red iron ochre; in quartz, and fre-
“ quently with greenish clay, having in-
“ termixed chlorite.

“ 8th *Formation*. Lead glance rich in
“ silver, with yellow blende, fahl ore, and
“ common iron pyrites; in brown spar
“ and quartz.

“ 9th, *Formation*. Lead glance poor in
“ silver, with radiated iron pyrites, and
“ rarely brown blende; in heavy spar,
“ fluor spar, sometimes a little calc spar,
“ and quartz.

“ 10th *Formation*. Lamellar lead glance
“ and compact lead glance, with a little
“ black blende, iron pyrites and sparry
“ iron stone.

“ 11th *Formation*. Lead glance, with
“ much brown blende and sparry iron
“ stone, and also some iron pyrites, fahl
“ ore, and a little copper pyrites; in
“ quartz.

“ 12th *Formation*. Lead glance, with
much dark brown blende; in quartz.

“ 13th *Formation*. Lead glance, with
“ small and fine grained dark brown
“ blende, iron and copper pyrites, and
“ quartz.

“ 14th *Formation*. Lead glance, with
“ copper pyrites; in calc spar.

“ 15th *Formation*. Lead glance, with
“ much dark and a very little light red

“ silver ore, cobalt, and native arsenic ;
 “ in calc spar.

“ 16th *Formation*. Lead glance, with
 “ calamine, and much brown iron ochre.

“ 17th *Formation*. Lead glance very
 “ poor in silver, very small in quantity,
 “ sometimes disseminated, sometimes in
 “ membranes, with copper pyrites ; in
 “ calc spar*.”

As the observations that follow the preceding excellent determinations will be of great use to those who are inclined to pursue this interesting branch of geognosie, I shall insert them here. “ Parmi ces diverses formations de galene (lead glance) il y en a cinq, que l’on voit principalement dans les Hartz : mais il est extrêmement difficile de pouvoir juger avec exactitude des ces formations,

Observations
on the me-
thod of de-
termining
vein forma-
tions.

* Nouvelle theorie de la formation des filons, par
 A. G. Werner, p. 186 to 192.

“ lorsqu'on n'a pas vu soi même (et c'est
“ les cas, ou je me trouve a l'égard des
“ ces formations du Hartz) les gites même,
“ ou elles se trouvent ; car il ne suffit pas
“ d'avoir vu des échantillons d'un forma-
“ tion, pour pouvoir en juger sainement ;
“ il faut avoir vu exactement et plusieurs
“ fois les gissemens ou local, ou elles se
“ trouvent, avoir examiné l'ordre et l'en-
“ semble des fossiles qui appartiennent a
“ une même formation, avoir observé les
“ variations, que cette formation éprouve
“ en divers endroits, ainsi que la disposi-
“ tion des gites, qui les renferment. Ce
“ n'est que par des observations exactes
“ et répétées, par des comparaisons faites
“ avec soin, que l'on reconnoitra que deux
“ formations, qui paroissent se ressembler
“ ne peuvent être regardées comme une
“ même formation a cause des différences
“ essentielles qu'elles présentent ; que des
“ variations qu'éprouve une même for-
“ mation doit la faire subdiviser en plu-
“ sieurs autres ; que plusieurs autres que
“ l'on trouve ensemble dans un même

“ lieu ou gite, ne doivent cependant
 “ etre considerées, que comme apparte-
 “ nant a une meme formation principale.
 “ Ainsi il pourroit bien se faire que ce que
 “ j’ai dit sur le formations du Hartz vint
 “ à eprouver quelques corrections, ou
 “ recevoir quelques additions. Peut-etre
 “ en faisant et continuant des observa-
 “ tions soignées dans des pays differents
 “ et meme éloignés les uns des autres
 “ on decouvrira un beaucoup plus grand
 “ nombre des formations de galene.”

According to General Dirom, the ^{Produce of} mines belonging to the Earl of Hope-^{the mines.} toun produce annually 1400 tons, and those of Wanlock-head, belonging to the Duke of Queensberry, about 1000 tons, worth L. 20. per ton, or in all L. 48,000. yearly. The proprietors receiving every sixth bar as lordship or rent.*

* General Dirom’s Mineralogical Description of Dumfries-shire, annexed to the county map.

Nearly at the entrance of the valley of Leadhills, there is a mighty rock mass of flinty slate, through which none of the veins have been observed to pass; indeed it is said by the miners to cut them off.

Veins cut off
by a rock
mass of flinty
slate.

In the Hartz, and other mining countries situated in transition rocks, similar appearances have been observed.

Friesleben, in his description of the Hartz, speaking of the interruptions produced in the mining field by flinty slate, gives the following instance which he himself ob-

Similar phe-
nomenon in
the Hartz
mines.

served. “ Sie schneidet nun den Sam-
“ oner gang gegen Nw-ab; denn dieser
“ setzt zwar noch einige lachter in selbige
“ hiercin, kan aber wegen der festig-
“ keit dieses gesteins nicht ununterbro-
“ chen in demselben forsetzfen, sondern
“ setzt sehr haufig ab, legt sich niern-
“ weisse wieder an, und ist überhaupt
“ schmall und taub; auch dauert dieses
“ gar nicht lange, sondern bald schneidet
“ sich der gang in ihm gänzlich ab.
“ Ein einziges mal fanden wir ihm so
“ gar erz fuhrend in der Ruschel (Kief-

“elſchiefer) dies war nãhmlich in den
 “neufangner Fürſtenbau woſelbſt er ge-
 “diegen arſenick, roth giltigerz und
 “kalkſpath führte *.”

As the ores of lead are the moſt remarkable mineral productions of this formation, I ſhall now give a ſhort deſcription, which will include all the varieties I had an opportunity of obſerving in the veins themſelves, or in the collection of Mr Taylor of Wanlock-head, the mine-maſter of the diſtrict.

I. WHITE LEAD ORE.

Its colours are ſnow white, yellowiſh white, and greyiſh white: from ſnow white, it paſſes through greyiſh white into aſh grey, and from yellowiſh white into cream yellow, and pale clove brown ?

* Bemerkungen über den Harz, von Johann Carl Frieſleben.—Zweiter Theil. ſ. 245.

1. It occurs in six-sided prisms, acuminate on both extremities with six planes, which are set on the lateral planes. Sometimes the extremities of the accuminations are truncated; sometimes the prism is so short that the crystal appears like a double six-sided pyramid.

2. Sometimes in the form of four-sided prisms, acuminate by four planes, which are set on the lateral planes, like zircon.

3. The six-sided prism is sometimes much compressed and stellularly intersecting.

4. Long four-sided table, bevelled on the smaller terminal planes, and the edge of the bevelment truncated. It sometimes occurs in twin crystals.

The crystals are sometimes columnar aggregated, and this variety has been confounded with columnar heavy spar.

Externally its lustre is splendid, seldom shining; internally it is from splendid to glisning, and is adamantine.

Fracture is commonly small conchoidal, but it sometimes passes to fine-grained uneven, and even to splintery.

Fragments are indeterminately angular.

Is usually translucent, but in crystals semi-transparent. Streak is greyish white.

Is soft. Not very brittle. Easily frangible. Heavy. Specific gravity—7,2357. Chenevix.

Constituent Parts.

According to Klaproth, it contains—

Lead	77
Carbonic acid	16
Oxygen	5
Loss, and water of crystallization	2

100.0

Observations.

The columnarly aggregated variety has some resemblance to columnar heavy

spar, but is easily distinguished from it by fracture, lustre, and weight, and also by its geognostic characters.

II. GREEN LEAD ORE.

Its colour is grass green, which passes on the one side through pistacio green, olive green, and silk green, into sulphur yellow: on the other side, through asparagus green into greenish white. Some varieties approach to leek green. The olive and pistacio green colours are the commonest.

It occurs massive, sometimes kidney-shaped and botroidal, but is most commonly crystallized.

1. Six-sided prism, having sometimes the lateral and terminal edges truncated. When the truncations on the terminal edges increase, a six-planed acumination is formed.

2. When the lateral planes converge towards the extremities, an acute double six-sided pyramid is formed.

The prisms are usually low, and sometimes hollow at the extremities.

Sometimes it occurs in beautiful velvety druses.

Crystals are small and very small, seldom middle-sized; and are often scalar-wise aggregated.

Externally it is smooth, and shining; internally glistening and resinous.

Fracture small-grained uneven.

Fragments indeterminately angular sharp edged. Heavy.

In other characters it resembles the preceding species.

Constituent parts of that found at Wanlock-head.

Oxyd of lead	80.
Phosphoric acid	18.
Muriatic acid	1. 62.

Klaproth.

Observations.

1. This species, when it has a very pale greenish-white colour, is apt to be confounded with the preceding species; but we can always distinguish them by the following characters:—1. The fracture in this species is fine-grained uneven, but in white lead ore, is more or less perfectly conchoidal. 2. Its lustre is resinous, but that of white lead ore is adamantine. 3. It possesses greater specific gravity than white lead ore. 4. Its crystals are often scalarwise aggregated, which is never the case with white lead ore; and 5. Its prisms are generally shorter than those of white lead ore.

2. Mr. Klaproth having found phosphat of lead or green lead ore of a greyish white colour, proposes it as an objection to the naming of minerals from their colours. It must be remembered, however, that the name does not imply the constant occurrence of a green colour; it only intimates, that the green colour

is the most striking feature in the external aspect of the mineral, and that it occurs more frequently than any other colour.

III. LEAD EARTH.

I. SUBSPECIES.

White Lead Earth.

Colour is yellowish grey.

Occurs massive.

Lustre is glistening, passing to glimmering and dull, and is adamantine, passing to resinous. Fracture fine-grained uneven, passing sometimes to conchoidal, sometimes to fine earthy. Opaque. Streak brown. Soft, passing to very soft. Not very brittle, approaching to mild. Easily frangible and heavy.

Geognostic Character.

It occurs along with white lead ore.

II. SUBSPECIES.

Friable Lead Earth.

Colour is yellowish grey.

Is composed of dull dusty particles, that soil a little. It is meagre and rough to the feel.

Is more or less cohering.

Observations.

1. It is to be observed passing to the preceding subspecies.

2. It occurs along with lead glance, white lead ore, and solid lead earth.

3. It is probably formed by the decomposition of lead glance, because it occurs almost always as crust on it.

IV. LEAD GLANCE.—GALENA.

Of this species, both the common and compact subspecies occur. But of these, it is not necessary to give any description.

LEAD VITRIOL—SULPHAT OF LEAD.

In the collection of Mr Taylor, there are some specimens of the tabular variety mentioned by Klaproth, which contains in the 100 parts—

Oxide of lead	70	50
Sulphat of lead	25	75
Water of crystallization	2	25
	<hr/>	
	98	50

Klaproth's Beiträge.

About ten years ago, a vein of grey ^{Antimony} antimony ore was opened in Glendinning: ^{mine of Glen-} ning in Eskdale. The working was continued for some time with much profit to the adventurers, but it has been lately given up, it is said, owing to want of

skill in the miners and energy in the proprietors. The vein traverses grey-wacke; but its extent, direction, dip, or width, I was not able to ascertain, as the workings had fallen in. The *vein stones* are quartz, and calc-spar; the *ores* grey antimony, brown blende, fine-grained lead glance, and iron pyrites.

In the mass of the vein, I found intermixed fragments of grey wacke and grey wacke slate. The ore of antimony is the radiated grey antimony, which, according to Bergman, contains in the hundred parts—Antimony 74,00; Sulphur 26,00.

This ore, according to the observations of Werner, is of a middle age. He has not observed it in the floetz rocks, nor in the older primitive.

The only other appearance of ore which I observed, was in the parish of Tundergarth, on the estate of Mr.

Murray of Murrayfield. The ore is iron mica ; but as the ground was overgrown with grafs, and no trial of any consequence had been made, I cannot at present give a more particular account of it.

Lead ore is also said to have been found on the farm of Westwater, belonging to the Duke of Buccleugh, and in the estate of Broomholm, belonging to J. Maxwell, Esq.*

Observations.

I. Although these are the only repositories of ores hitherto observed in this county, it is not to be doubted that a more careful examination of all its mountains and valleys may discover many others. Even if after a complete and careful survey no metalliferous mineral repositories of consequence should be discovered, it does not follow that ores will not be found in these mountains ; on the contrary, from

Observations to shew the advantages of a repeated examination of the same district.

* Note H.

the nature of the rocks of which they are composed, we have good reason for expecting, by the continual alteration produced on their surface by the action of frost, torrents, &c. that many metalliferous repositories, at present hid from us, will by these great natural mining operations be brought to light. At the end of every year the surface of the county is in a very different state from what it was twelve months before; it is therefore to be recommended to proprietors of landed property, who are skilled in mineralogy and mining, to examine their mountains and valleys every year, with the view of ascertaining whether or not repositories of ore have been laid open.

Limestone to be expected in the higher parts of the county.

2. No limestone beds of any considerable magnitude have as yet been discovered in the transition rocks of this county. In other countries where transition rocks abound, great depositions of limestone have been observed: thus in the

Hartz, the famous quarries of Blankenberg are situated in rocks of this kind; it is also found in the transition rocks of Voightland, Bareuth, Upper Bavaria, and extends even to the Tyrolese alps, and into Italy. In Scotland, considerable strata have been observed in the mountains between Noblehouse and the Crook. These facts encourage us to expect limestone in the transition rocks of this county.

It is also worthy of remark that the limestone which occurs in these rocks is not only well calculated for the purposes of cement and manure, but on account of its beautiful colour delineations, and the great thickness of its beds, is admirably fitted for architectural purposes. Many of the finest ancient ornamental works and edifices are constructed of transition limestone *.

Transition
limestone well
suited for ar-
chitectural
purposes.

* In this limestone there often occur great veins of ochry, compact, and hæmatitical brown ironstone, also brown iron-froth. The veins are usually

Coal does not
occur in tran-
sition rocks.

3. Coal, as will be more particularly explained afterwards, does not occur in transition rocks. Now and then small beds of slaty glance coal* are found, but these in an œconomical point of view are of no importance.

Trials made
for coal in
transition
rocks.

About half a mile from the manse of Kirkmichael there is a rock of alum slate which has interspersed through it iron pyrites. This appearance was considered as indicative of coal, and a trial was made. I have been informed that similar trials have been made in other parts of the transition country: a knowledge of the rocks, however, would have prevented all such unnecessary experiments.

from two to three fathoms wide; the ore yields from forty to seventy per cent. of an iron which is excellently fitted for steel making.

* Slaty glance coal was formerly known by the name coal blende.

INDEPENDENT COAL FORMATION*.

Eigentliche Steinkohlen Formation of
Werner.

Coal occurs in single beds in several of the older sandstone formations, Different formations of coal. but it is only found in quantity in the independent coal formation, the newest floetz trap formation, and the alluvial formations. The rocks that constitute and characterise the independent Rocks of the independent coal formation. coal formation, the only one that at present interests us, are, according to Werner, the following: 1. Coarse conglomerate. 2. Loosely aggregated sandstone, which although it is sometimes very solid, is always micaceous. 3. Slate clay. 4. Bituminous shale. 5. Lime-

* This formation is called independent, because it exists independent of any other, whereas the coal found in the older sandstone, floetz-trap, and alluvial formations, is to be considered as subordinate to or dependent on them.

stone. 6. Marle. 7. Common indurated clay. 8. Clay iron-stone. 9. Porphyritic stone.

Different formations subordinate to the independent coal formation.

This formation, however, includes several subordinate formations, which are distinguished from one another by the rocks of which they are composed, and their relative antiquity. Thus the newest of these formations is composed of loosely aggregated sandstone, conglomerate, and slate clay; one somewhat older of indurated clay, marle, limestone, and porphyritic stone; and another, such as that of Mid Lothian, of slate clay, limestone, marle, soft sandstone, and greenstone, which is probably the oldest.

The independent coal formation does not lie under the old red sandstone.

It was first asserted by the celebrated miner Lehman, that coal is usually found under or in the *old red sandstone*, and since his time this opinion has been supported by several able mineralogists, as Karsten, Von Buch, Voight, and Friesleben. Werner, however, has shewn that this posi-

tion is false, and that the independent coal formation does not lie under the *old red sandstone* formation.

From the prevailing reddish brown colour of the sandstone in the lower part of the county, and its vicinity to the old red sandstone of Cumberland, I was for some time doubtful whether or not it might not belong to the same formation. A careful examination, however, convinced me that my suspicions were unfounded, and that not only the sandstone in the lower part, but also that in several other places situated in the upper part of the county, belonged to the independent coal formation. As on the accurate determination of this point depends the probability of coal being found in this county, I shall endeavour in the following observations to give it all the elucidation of which I am capable. To do this I shall 1st, give a description of the formation in this county. 2d, That I may be able to contrast it with some

Plan to be followed in describing the coal formation.

other well known coal formation, I shall next give a short description of the coal field of Mid Lothian; and 3d, I shall contrast these two fields, and shew in what they differ and in what they agree, and if they are to be considered as part of the same formation.

COAL FORMATION OF DUMFRIES-SHIRE.

Stretch of
the strata.

The general stretch of the strata of this formation in the lower part of the county is from east to west, and the dip towards the south, and seldom under a greater angle than 40° . In the higher parts of the county, the stretch and inclination of the strata is very much varied, owing to their vicinity to the transition rocks.

Rocks of
which it is
composed.

The rocks of which it is composed are, 1. Sandstone, 2. Slate clay, 3. Bituminous shale, 4. Limestone, 5. Clay ironstone, 6. Coal, and 7. Limestone conglomerate.

1. *Sandstone.* Colour reddish brown, brick red, sometimes yellowish grey, greyish white, and sometimes marked with reddish brown coloured delineations.

The grains of which it is composed, which are of quartz, are from the size of a poppy seed to that of a bean and even larger. When it passes into conglomerate, the fragments are larger, and besides the quartz, contain fragments of amygdaloid, transition slate, grey wacke, and rarely hornstone. Sometimes it also contains mica, which is frequently in such quantity that it has a slaty fracture, or to speak more correctly, it rises in plates. Sometimes, as in the quarry between mount Annan and the village of Annan, also in the parish of Closeburn, the mica is so abundant that the sandstone approaches to that variety which is termed by Werner sandstone slate, and which occurs principally in the first and second sandstone formations. The fragments are connected by a basis of iron

clay, which is sometimes in such quantity that it passes into clay iron-stone.

It is more or less friable ; that of Corn-cocke muir, Brown muir hill, and Can-noby is very friable ; that quarried at the Cove is of good building consistence ; in other situations, as Ecclefechan, owing to the preponderance of a basis of clay iron-stone, it is rather tough. Sometimes there are patches of several hundred square feet of a greyish white coloured sandstone included in the reddish brown sandstone ; of this there is a striking instance at the Cove. We have it on a smaller scale in other parts, where the patches are not many feet, sometimes only a few inches square.

It sometimes contains vegetable impressions or casts resembling those found in the coal field of Mid Lothian.

Sometimes the sandstone, particularly that found in the coal deposition of Can-

noby, consists of spherical concretions, which are again composed of curved lamellar concretions*.

2. *Slate clay*, which lies between the beds of reddish brown coloured sandstone, presents the following characters:

Colour yellowish grey, marked with spotted and clouded delineations of a pearl grey and cherry red colour.

Internally it is dull or glimmering, owing to intermixed scales of mica.

Fracture more or less perfectly flaty, sometimes approaching to earthy.

Fragments indeterminately angular, sometimes tabular.

Opaque. Soft. Mild. Easily frangible. Feels meagre.

At Ecclefechan, Repentance-hill, Whitehill, Cannoby, and Sanquhar, I observed greyish black and ash grey coloured varieties, which contain numerous impres-

* Note I.

sions of shells, and sometimes also of ferns *.

3. *Limestone.* Its colours are bluish grey, pearl grey, and reddish brown.

Lustre glimmering.

Fracture fine splintery and minute foliated.

Scarcely translucent on the edges.

It contains numerous petrifications, as milleporites, chamites, mytulites, trochites, entrochites, &c.

It is distinctly stratified, and the strata are from six inches to several feet thick †. It frequently contains hollows, which are usually filled with clay.

4. *Clay iron stone.* That of Ecclefechan presents the following characters :

Colour brick red, and reddish brown.

Occurs massive.

Lustre dull, or feebly glimmering, owing to an admixture of foreign particles.

* Note K.

† Note L.

Fracture fine earthy, even sometimes passing to large and flat conchoidal.

Brittle, passing to mild.

Scratched pretty easily by the knife.

Heavy.

In the coal field of Cannoby, spherical shaped masses of clay iron-stone occur imbedded in slate clay. These spheres are from a few inches to three feet in diameter, and do not differ in any respect from those found in the coal field of Mid Lothian*.

5. *Limestone conglomerate.*

Is composed of fragments of compact greyish coloured limestone, quartz, and grey-wacke, cemented by a clayey basis.

6. *Coal.*—The coal which is worked at Cannoby and Sanquhar, the only spot where it has been found in quantity, appears generally to be intermediate be-

* Note M.

tween slate and pitch coal, sometimes inclining more to the one, sometimes more to the other. Intermixed with it we frequently meet with

MINERAL CHARCOAL,

which presents the following characters.

Colour greyish black.

Lustre glimmering, bordering on gliftening, and is pearly or silky.

Fracture fibrous; sometimes shews the woody texture.

Fragments indeterminately angular, blunt edged, and partly splintery.

Soils strongly. Soft, passing into friable. Light.

It occurs in thin layers in the coal, or disseminated through it.

More particular account of the distribution of the coal formation.

This formation, as already mentioned, occupies a considerable portion of the bottom of the valley of Sanquhar and Kirkconnel, and there it rests on transi-

tion rocks. Several beds of slate coal are worked at Sanquhar and Kirkconnel; and the quantity raised is sufficient to supply the county for many miles round. The deposition here distinguishes itself from that of Closeburn, by the greyish white colour of its sandstone; greyish black colour of its slate clay, and the general thinness of its beds.

A little above Crawick bridge, Mr. Taylor of Leadhills pointed out to me a remarkable mineral, which may be denominated *columnar glance coal* *. It is to be observed passing to graphite, but not so distinctly as near Cumnock in Ayrshire, where there is a graphite mine †. It forms a bed about four feet thick in the coal formation, and is traversed by a vein (dyke ‡) of greenstone. This vein, as is

* Note N. † Note O.

‡ Common miners in Scotland, struck with the resemblance of veins to walls, gave them the name, *dyke*. As this term is local, to say nothing worse of

often the case, has produced a shift in the strata.

Clofeburn.

A considerable portion of the valley of Clofeburn is occupied by the same formation which extends in one direction from Drumlanrig to a little beyond Brownmuir inn. The beds and strata are thicker than in the valley of Sanquhar, and the sandstone and slate clay has usually a reddish brown colour. At Clofeburn and Barjarg there are considerable quarries of limestone, which afford good opportunities for examining this rock. The limestone is distinctly stratified; the strata are from two to upwards of three feet thick, and frequently interposed between them we observe thin seams of bluish grey and reddish brown coloured clay. In several of the strata there are irregular holes, which are sometimes empty, but more frequently filled with a kind of clayey loam and brown

it, it should be abolished, and the universally understood and generally adopted word *vein* substituted in its place.

ochre of iron, intermixed with manganese. In this character the limestone agrees with that near Vogrie in the county of Mid Lothian. Sometimes we observe in it beautiful dendritic brown iron hæmatites. I am indebted to the intelligent Mr. Monteith of Clofeburn for several beautiful specimens of this kind. The limestone is generally of a flesh-red and pearl grey colour, and its fracture is fine splintery. It contains petrifications of various kinds, particularly large ammonites.

The extensive quarries of Barjarg do ^{Barjarg.} not differ from those of Clofeburn, and are most evidently part of the same deposition. It is highly probable that this limestone will be found to extend through the whole of the coal formation of this valley.

A considerable portion of the lower ^{Valley of Dumfries.} and flatter part of the valley of Dumfries is composed of reddish brown coloured sandstone, belonging to the independent

Craigs near
Dumfries.

coal formation, which is distinctly stratified, but contains no strata of other minerals, excepting the strata of limestone at Comlongan near the shore of the Solway frith. The rocky cliffs near the town of Dumfries, called the Craigs, are composed of sandstone conglomerate, which rests on the reddish brown sandstone, and evidently belongs to the same formation, because we observe interposed between the beds of conglomerate thin beds of reddish brown coloured sandstone. This conglomerate is composed of angular and blunt-edged fragments of syenite*, grey wacke, and grey wacke slate, which are immersed in a basis composed of fragments of quartz, grey wacke, and grey wacke slate, which are connected together by a kind of iron-clay.

Coal formation in the district of Annandale.

In the district of Annandale we meet with patches of this formation as high up as Hartfell. The reddish brown co-

* Note P.

loured sandstone stretches from the basis of Hartfell, the highest mountain in this county, towards Moffat, where it forms the beautiful eminence called Chapel-hill; it makes its appearance again at the Bald craig, about three miles south-east from Moffat. It is to be observed also between Moffat and Rae-hills, the seat of the Earl of Hopeton.

At Corncockle muir, about three miles ^{Corncockle muir.} north of the burgh of Lochmaben, there are strata of reddish brown coloured sandstone. Several of the strata can be raised in flags and plates so thin, that they are used for paving, and even for roofing houses.

The formation makes its appearance again at the Rotchel, below the manse of Saint Mungo, and continues from that point to the shores of the Solway frith, and extends through the lower part of Annandale to Eskdale. In the lower part of the district of Annandale, that is, beyond

the valley of Annan, there are several places where this formation is to be distinctly seen; with a short description of these I shall finish the account of its distribution in Annandale. The places are Kellhead, Ecclefechan, Brown muir, Brown muir hill, Repentance hill, Blacket rig, Cauldron lins, and High muir quarry.

Kellhead.

At Kellhead there is an extensive quarry, where a great rock mass of limestone is exposed: it is distinctly stratified, and strata are sometimes separated from each other by thin seams of slate clay. In some of the strata I observed small cavities, resembling those in the limestone of Closeburn and Barjarg, filled with clay. It is traversed by veins of calc-spar, and sometimes there are small cavities lined with crystals of calc-spar. The crystals have a yellowish grey colour, and their figure is a double six-sided pyramid acuminated by three planes which are set on the alternate lateral planes. It also contains numerous petrifications, as corallites, chamites, and mytulites.

Immediately behind the village of Eccle- Ecclefechan. fechan, in the channel of the rivulet that runs by the limestone quarries, there are beds of clay iron-stone alternating with greenish grey and reddish brown coloured slate clay, and covered by reddish brown coloured sandstone. The beds of iron-stone are from three inches to a foot thick. Immediately above this we come to the *first limestone quarry*, where we observe thin beds of clay iron-stone, pearl grey coloured slate clay, and sandstone, resembling that of Brown muir, lying on beds of slate clay that alternate with beds of limestone containing numerous petrifications, but principally mytulites, chamites, and corallites. In the *second limestone quarry* there are beds of limestone from one to two feet thick, alternating with beds of greyish black coloured slate clay, and of greyish white coloured sandstone. The slate clay is sometimes so compact that the slaty texture is difficultly discoverable. Much mica is intermixed with the sandstone.

In the upper or third quarry the beds are composed of the same materials with the second.

Repentance
hill.

In 1791 a trial shaft was sunk to a considerable depth in this hill, in search of coal; it passed through several beds of greyish white and reddish brown coloured sandstone; of greyish black and reddish brown coloured slate clay, and in which there were beautiful impressions of ferns, and some thin seams of pitch coal *.

Brown muir
hill.

Brown muir hill is composed of greyish white and reddish brown coloured sandstone, which is rather of a loose texture, and sometimes contains pretty large fragments of quartz, and also masses of clay. It alternates with beds of pearl grey coloured slate clay, which has much mica intermixed, and it contains vegetable impressions.

* See General Dirom's section in the county map, for a more particular account of this trial.

In the Brown muir there are several ^{Brown muir limestone.} quarries, where the limestone belonging to this formation is well exposed. In all these quarries the limestone is stratified, and between the strata, as usual, there are thin seams of greyish black, greenish grey, and mountain green coloured clay. The strata are from six inches to three feet thick, and often present hollows filled with clay, like the limestone of Closeburn, &c. It contains similar petrifactions with that of Closeburn, but some species in greater quantities than others, particularly the milleporites, which is found in great quantity, not only in the limestone, but also in the slate clay, and in no place more abundant and beautiful than in the limestone quarries on the estate of Brigadier General Dirom.

Linbridge ford. In 1793, 4, and 5, according to General Dirom, trials were ^{Linbridge ford.} made at this place, with the view of discovering coal, and they appear to have reached the depth of 140 feet. The rocks

passed through were greyish white, yellowish grey, and reddish brown coloured sandstone; greyish black and reddish brown coloured slate clay; greyish black bituminous shale, and a bed of coal about four inches thick. For particulars see general section in the county map.

Blacket rig. At Blacket rig, which is situated on the border of the transition rocks, there is an extensive limestone quarry, where the limestone, as usual, is distinctly stratified, and the strata frequently separated from each other by thin seams of a bluish grey and mountain green coloured clay. The strata are from two to six feet thick, and in some strata the limestone is so intermixed with clay that it acquires a brecciated aspect, and on working it separates easily into masses of various sizes. Such strata are easily worked, and the limestone is considered to be of a better quality than the more solid strata. It has the same external characters, and

contains similar petrifications with the limestone of the Brown muir.

Cauldron linns. About a mile and a ^{Cauldron}
half further to the eastward there is another quarry of limestone, called ^{linns.} Cauldron linns. The limestone is distinctly stratified, and the strata are separated from each other by thin seams of clay, and in some strata, from the intermixed clay, it has a brecciated aspect. The strata are from six inches to a foot and a half thick, and are very distinctly and beautifully *trough-shaped*. It has the same external characters, and contains similar petrifications with that of the Brown muir, &c.

High muir quarry. About half a mile ^{High muir}
to the north east of this there is another quarry. quarry. called High muir. In it the limestone exhibits very beautiful *trough-shaped stratification*. The strata are seldom above three feet thick, and are usually separated from each other by very thin seams of clay. In the upper part of the

quarry the limestone is covered by thin strata of greyish coloured sandstone, which contains much mica, and it also presents very beautiful trough-shaped stratification.

It is probable that the limestone of Brown muir, &c. stretches through a great extent of the low part of the district of Annandale.

Coal formation in the district of Eskdale.

Eskdale, as I have already mentioned, is almost entirely composed of transition rocks, from its upper part to Langholm bridge. There the coal formation begins and continues through the whole of the lower part of this district to the Solway frith. Between Langholm bridge and Byre burn the sandstone is usually of a greyish white and yellowish grey colour, and contains many vegetable moulds. The limestone is usually bluish grey, and contains many petrifications. The slate clay is usually greyish black, and contains beds of globular clay iron-stone; and the bituminous shale has the usual characters. Below Byre burn the brown-

ish red coloured sandstone commences, and continues without any alternation of other rocks to the Solway frith. The strata in the coal field of Byre burn are frequently trough-shaped. At present three beds of slate coal are worked*.

Having now detailed with sufficient minuteness the characters of the different rocks of the coal formation of this county, I may now add, that its most striking characters are, the reddish brown colour of the sandstone, the great thickness of

* The coal of Cannoby, Sanquhar, and Kirkconnel, is that variety of slate coal which contains much bitumen, and therefore, when inflamed, cakes; hence it is called caking coal. It is particularly useful for the forge and in domestic æconomy, but would not answer so well in other operations, as in smelting ores, &c. because of its running so close together. The varieties used for burning limestone contain much intermixed bituminous shale and slate clay; this intermixture, in place of being detrimental, is of advantage, as the fire remains open during combustion. Even the bituminous shale, which is thrown away among the refuse, might be used for burning limestone.

its strata, the paucity of subordinate beds, and the thinness of its beds and strata, when beds of iron-stone occur, of which we have examples at Ecclefechan, White hill, Byre burn, and Sanquhar.

COAL FORMATION OF MID LoTHIAN.

Coal field of
Mid Lothian.

I shall now give a very short account of the coal field in the neighbourhood of Edinburgh, or what is termed Mid Lothian.

The Edin-
burgh coal
field rests on
transition
rocks.

The basis on which the coal formation rests is transition rocks, and these agree very much in their characters with those of Dumfries-shire. The strata and beds are generally thin; they dip in various directions, according to the inequalities over which they are deposited.

The rocks of which it is composed are,
1. Sandstone, 2. Slate clay, 3. Limestone,
4. Clay iron-stone, 5. Limestone conglomerate, 6. Coal, 7. Clay stone, 8. Bitu-

minous shale, 9. Green stone, 10. Indurated marle.

1. *Sandstone* is yellowish grey, ash grey, greyish white, ochre yellow, yellowish brown, and sometimes reddish brown, approaching to cochineal red*. The grains of which it is composed are usually quartz, and are from the size of a poppy seed, to that of a bean, and even larger. Sometimes it contains mica, and grains of felspar. The fragments are connected by a basis of clay, which is sometimes more or less impregnated with iron, and to which it in general owes its various coloured clay, and also interspersed iron pyrites. Its compactness or solidity is very various, sometimes it is friable, in other instances of good building consistence, and sometimes, although rarely, it has a basis of quartz, and thus forms flinty sandstone.

* Note Q.

It often contains vegetable impressions, but the plants to which they belong have not hitherto been determined. Indeed no experienced botanist has, as far as I know, made them the object of his particular attention. It also frequently contains pieces of bituminous wood.

2. *Slate clay* is of various colours, but principally inclining more or less to black, and sometimes, particularly where the reddish brown coloured sandstone occurs, it has a reddish or brownish tinge.

3. *Limestone*. Colour usually grey. Has a splintery fracture, and is sometimes very minutely foliated. Is faintly translucent on the edges. It often contains petrifactions of various species of shells, and sometimes also, but rarely, vegetable impressions and pieces of bituminous wood.

4. *Clay iron-stone*. Of this no description is necessary, as it resembles completely that found in Dumfries-shire.

5. *Limestone conglomerate*. This is identical with that found in Dumfries-shire.

6. *Greenstone* *. Its colours are usually blackish green, and greenish black, and, when the felspar predominates, greenish grey; it is even sometimes nearly ash grey. It is composed of hornblende and compact felspar, and of which the hornblende usually predominates; sometimes, however, the felspar predominates to nearly the entire exclusion of the hornblende †.

7. *Clay stone*. Colour smoke, ash, and pearl grey, and from pearl grey it passes into brownish red and brick red.

Occurs massive.

Fracture generally fine earthy, sometimes splintery, and sometimes inclines to conchoidal.

Fragments indeterminately angular.

* Note R.

† Note S.

Is opaque.

Soft.

Not particularly brittle.

Pretty easily frangible.

Feels rather meagre.

Does not adhere to the tongue.

8. *Bituminous shale.* Its colour is brownish black.

Occurs massive.

Internally its lustre is glimmering.

Fracture straight flaty.

Fragments tabular.

Streak shining, but its colour is unchanged.

Very soft. Rather mild. Feels rather greasy.

Easily frangible. Not particularly heavy, approaching to light.

9. *Indurated marl.* Colour yellowish grey.

Lustre dull, and sometimes glimmering, owing to intermixed particles.

Fracture earthy, and sometimes flaty.

So soft as to yield to the nail.

Not particularly brittle.

Easily frangible.

Not particularly heavy.

10. *Coal.* Is usually intermediate between pitch and slate coal; sometimes beds of cannel coal occur, and very often we meet with native mineral charcoal.

From the preceding description it appears that the coal field of Mid Lothian agrees with that of Dumfries-shire, in containing nearly the same kinds of strata and beds; but the general character of the one is considerably different from that of the other. The strata and beds in Dumfries-shire are thick, those in Mid Lothian thin; the sandstone in Dumfries-shire is usually of a reddish brown colour, whereas that of Mid Lothian is grey; clay iron-stone occurs abundantly in Mid Lothian, but sparingly in Dumfries-shire; there occur beds of

General characters of the
Dumfries-
shire and
Mid Lothian
coal fields:

greenstone and clay stone in Mid Lothian, but these have not been observed in Dumfries-shire.

The agreements of these two fields, however, by far exceed the differences I have just mentioned, and shew that the formation of Dumfries-shire belongs to the independent coal formation, and render it probable that it is of the same age with that of Mid Lothian. Those to whom the geognostic data already mentioned do not convey conviction cannot withhold their assent to the conclusion just stated, when they read the following note respecting the extensive coal formation in Silesia, belonging to the king of Prussia.

Coal formation in Silesia.

In upper Silesia the coal formation is composed of *thin strata* of *greyish coloured fine-grained sandstone*, beds of *slate clay*, *clay iron-stone*, and *coal*, which is sometimes *six fathoms thick*. In lower Silesia,

on the contrary, the coal formation is composed of *thick strata of reddish brown coloured sandstone*, which is usually coarse grained, and indeed sometimes passes to conglomerate. Alternating with it we find beds of slate clay, and *thick and very extensive beds of coal*. Thus the coal fields of upper and lower Silesia present differences resembling those that distinguish Mid Lothian from Dumfries-shire, yet they are portions of the same formation.

I have therefore no hesitation in concluding that the coal fields of Mid Lothian and Dumfries-shire belong to the independent coal formation; and as coal has been found widely distributed in the one field, we are entitled to believe it occurs in quantity in the other.

Coal fields of Dumfries-shire and Mid Lothian belong to the same formation.

The particular spots where trials for coal may be made with the greatest economy and probability of success can only be ascertained by a careful survey of every hill, valley, rivulet, ditch, road, &c. where this formation

occurs. My object in this memoir is not to point out these spots, but to shew, according to the principles of sound geognosie, that the floetz sandstone of this county is not to be confounded with the old red sandstone, second sandstone, or third sandstone formations, but that it belongs to the independent coal formation; and therefore we are warranted in making trials for coal in any part of it, but with more probability of success in one situation than another *.

NEWEST FLOETZ TRAP FORMATION †.

The rocks of this formation are, according to Werner, wacke, basalt, greenstone, porphyry slate, and grey stone; and,

* Note T.

† The German term *flöetz*, which I am under the necessity of using, because we have no corresponding English word, is applied to all those formations which are contained between the transition and alluvial rocks. It implies that these formations are characteristically

as subordinate to it, gravel, sand, clay, flinty sand-stone, and coal. It is by him considered as the newest of the *universal* Floetz trap the newest of the universal formations. *formations*, because it reposes on all the others; and he has shewn that its internal structure, external aspect, and situation, can only be explained by a sudden rising and retiring of the waters of the ocean.

In this county several rocks belonging to this formation are to be observed, but I have not in any instance seen the complete series from gravel, through clay, wacke, to basalt and greenstone, as I have often witnessed on the mountains of Germany*. Here we have only individual links of the formation, and of these I shall now give a brief account.

distinguished by their frequent occurrence in beds (floetz). It is evident, therefore, that the words secondary, or tertiary, which have been proposed by some mineralogists, cannot be admitted.

* Note U.

Nutholm hill. Nutholm hill, which rises in three indistinct terraces above the manse of Saint Mungo, is composed of porphyritic amygdaloid. This rock can be traced on both sides of the river, down to the little hill called Whinny rig, where it terminates, and is succeeded by the coal formation. About a quarter of a mile west from Nutholm hill, on the banks of the river, the amygdaloid is to be observed lying on sandstone and slate clay, which is probably a portion of the coal formation. On the west side of the river amygdaloid does not stretch beyond the manse of Dalton; the ground to the west of the manse rises pretty high, and is composed of transition rocks. On descending the south-east side of Nutholm hill towards the water of Milk the amygdaloid soon disappears, and we do not meet with it again until we come to Barr hill, on its opposite bank. There it lies over a similar sandstone with that observed on the banks of the river near to Saint Mungo, and the sandstone rests on grey wacke. From

this hill it continues along the ridge by Newfield to Burnswark, and is to be observed in several places lying on a coarse conglomerate and sandstone, which again reposes on very much inclined strata of pretty compact small grained greywacke. On the north-west side of Burnswark, at Burnswark. a considerable height, I observed greyish coloured sandstone, marked with reddish brown coloured spots, and covered by slate clay; and on the north side, but higher up, I observed fragments of greyish white coloured sandstone, but the higher part of the hill is entirely composed of amygdaloid.

From this account it appears that the lower part of Burnswark is composed of sandstone, but the upper part of amygdaloid. Its basis is grey wacke and grey wacke slate.

Nearly in the same direction with Burnswark, above the limestone quarry called Blacket rig, the amygdaloid is to

be observed repofing on tranfition rocks ; and at Langholm bridge it occurs in a fimilar fituation. Thus it appears that the amygdaloid ftretches acrofs the lower part of the county from Dalton manfe to Langholm bridge, which is its fouth eaftern extremity. In all this courfe it is confined to the boundary, or the meeting of the tranfition rocks with the coal formation.

In the upper part of Annandale, as far as I have examined it, there are no rocks of this formation.

Carfoncone
hill.

In Nithfdale I obferved rocks of this formation at Carfoncone hill, which makes part of the ridge that feparates the county of Dumfries from Ayrfhire ; but in no other quarter of this extenfive diftrict, although it is not to be doubted that a careful examination will difcover it in many other parts.

At Todshaw hill and the hills called <sup>Pitchstone in
Eskdale</sup> Castle hill, Watch craig, and Wat carrick, ^{muir.} near the manse of Eskdale muir, which are composed of compact grey wacke, there are several summits covered with greyish black coloured pitchstone. The pitchstone is unstratified, and lies over the much inclined strata of grey wacke. In the same hills there is porphyry slate, which, like the pitchstone, occurs in globular and columnar distinct concretions. Sometimes *cotemporaneous* masses of pitchstone, are to be seen inclosed in the porphyry slate or basalt, and globular distinct concretions whose centers are pitchstone, but the surfaces, of a substance much resembling porphyry slate. We can also observe the transition from pitchstone to porphyry slate or basalt *.

This pitchstone, from its occurring along with porphyry slate, and lying over

* This pitchstone, like that of Glencloy, in the island of Arran, will probably be found to contain

transition rocks is to be referred to the newest floetz-trap formation *.

Observations.

Werner describes but one pitchstone formation.

Werner has hitherto described but one pitchstone formation, and it belongs to the primitive rocks. Several years ago I observed, in the highly interesting island of Arran, pitchstone alternating with floetz greenstone that lay over the inde-

bituminous or carbonaceous matter. The pitchstone of Glencloy, when powdered, emits a bituminous smell, and colours the sulphuric acid slightly. (Mineralogy of the Scottish Isles, vol. 1. p. 48.) Basalt and other rocks belonging to the same formation contain, according to Klaproth and Lampadius, bituminous or carbonaceous matter; and Mr. Pepys has discovered carbonaceous matter in wood opal and wood stone. Parkinson on Petrifications, vol. 1.

* Dr. Reufs of Bilin is of opinion that porphyry slate occurs in older formations than the floetz-trap; and Captain General Von Charpentier says that basalt sometimes occurs in primitive mountains. Both these observations, as I have shewn in my book on Mineralogy, are incorrect.

pendent coal formation * ; afterwards I saw it in veins traversing floetz-trap rocks in the isle of Egg †, and among similar rocks in the isle of Mull ‡.

Pitchstone
belonging to
the newest
floetz-trap
formation.

Since that time Werner has examined the black pitchstone of Zwickau in Upper Saxony, which he considers to belong to a similar formation. Mr. Humboldt, the celebrated and enterprising Prussian traveller, whilst on the summit of the Pic of Teneriff, observed beds of pitchstone among floetz-trap rocks ; and I have seen in the interesting collection of Captain General Von Charpentier specimens of a similar fossil that was found in the basaltic country of the Veronese. We have thus proofs that this pitchstone is subordinate to the floetz-trap formation, and that it is widely distributed.

* Mineralogy of the Scottish Isles, vol. 1. p. 23.

† Ibid. vol. 2. p. 44.

‡ Ibid. vol. 1. p. 213.

ALLUVIAL ROCKS.

Characters of
the alluvial
rocks.

The formations belonging to this class of rocks are, as Werner observes, all mechanical, if we except calc-tuff, which is an undoubted chemical precipitate. It differs from the other classes of rocks in the want of connection among its depositions, the looseness of the texture of the rocks of which it is composed, and the nearly total want of chemical precipitates. The number of its formations are also fewer.

Two alluvial
formations.

In this county we have two very distinctly marked formations; the first, or oldest, is the great mass of gravel which we find spread over the flat parts of the county, and through which the rivers now force their way; the second, or newest, is that which has been formed by the operations of the rivers themselves, and which is daily increasing by the continual washing of debris from

the neighbouring mountains. To this period we may also refer the accumulations of peat, which are also daily increasing.

In this alluvial land the only metallic mineral that has been discovered is *gold*. Gold found in alluvial land near the Leadhills. It was formerly washed for in the neighbourhood of Leadhills, and there is no doubt it exists in alluvial land in other parts of the county *. In Schwartzburg Rudolstadt gold used formerly to be washed out of the alluvial land formed by the decomposition of transition slate, as mentioned by Voight, who also observes, that it might probably still be extracted with advantage, if proper washing machines were employed †. This remark also ap-

* General Dirom, in his table annexed to the map of the county, informs us, that in the reign of James V. three hundred men are said to have been employed for several summers in washing for gold, and to have collected to the amount of L.100,000 sterling.

† Voight's *Kleine Schriften*, b. 2. f. 136, 7, 8, &c.

plies to the alluvial land of Dumfriesshire.

Gold of
Leadhills
probably oc-
curs in quartz
veins.

In what kind of repository was the gold of Lead hills formed, and in what species of rock are such repositories situated? The alluvial land in which the gold grains are found is composed of fragments of transition rocks, hence we may conclude that they formerly existed in these rocks; and, as the grains are sometimes found in quartz, and as quartz veins often traverse transition rocks, it is not improbable the greater part of the gold is derived from quartz veins*.

PEAT.

The most considerable accumulation of peat in this county is that in the valley

* All the gold found in Transylvania occurs in quartz veins that traverse transition rocks, a fact which renders the above supposition more probable.

of Dumfries, named Lochar mofs. It extends from Tinwald to Cockpool, at the mouth of the Lochar. It appears formerly to have been a lake, and not an inlet of the fea, as conjectured by fome. There are other accumulations of lefs extent, as that of Kilmore, that which extends from Burnfoot to Nellsfield, Righead mofs, and feveral others in the lower part of the county. In the upper or mountainous part of the county it is found in confiderable quantity in hollows between the mountains, and even on their fummits.

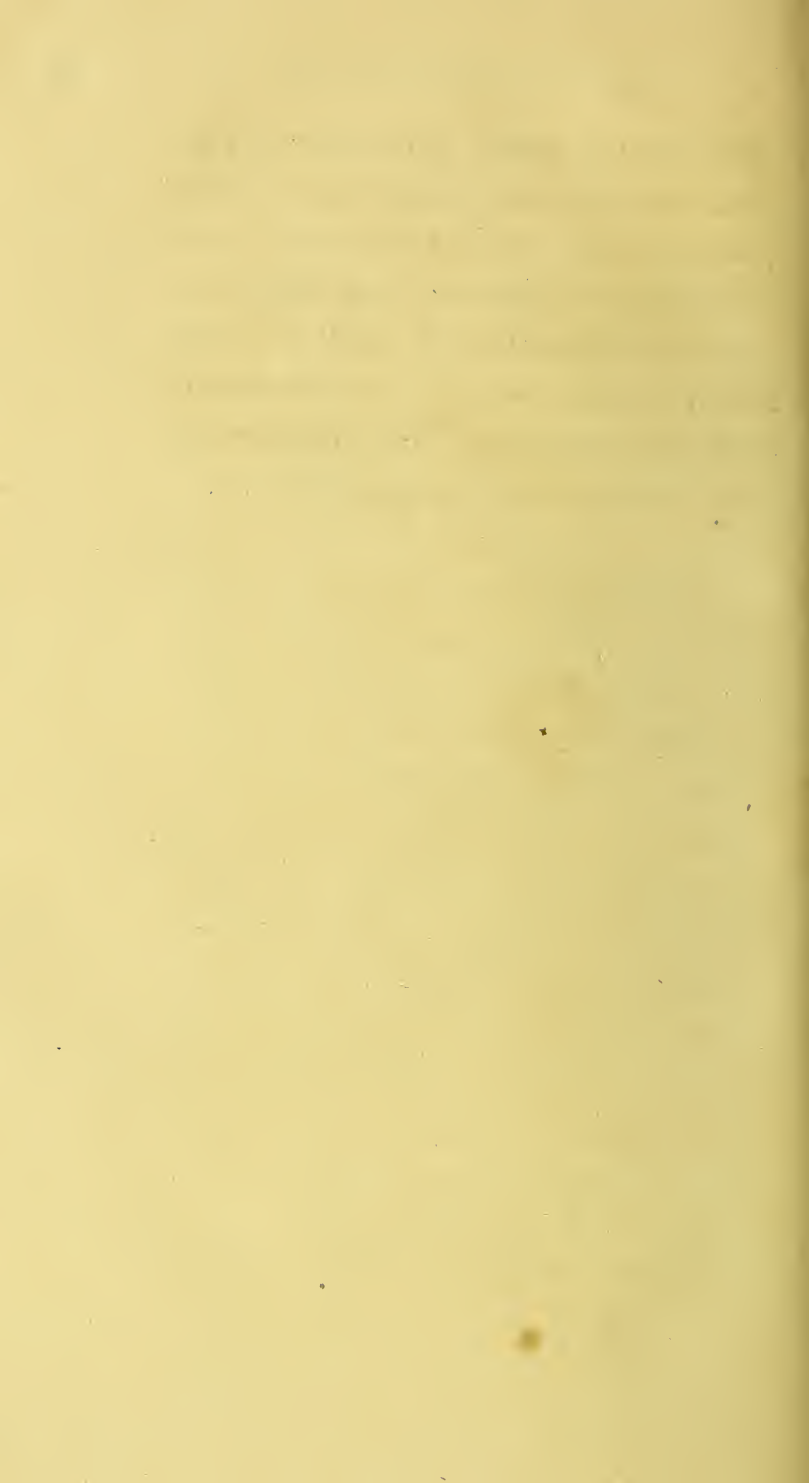
Observations.

The accumulation of peat on the fummits of high hills or mountains is a fact On the formation of alpine peat. deferving of attention. How are we to explain fuch accumulations of vegetable matter in fituations fo far removed from all the ufual fources of nourifhment? Is it not probable that water and air fupply thefe vegetables with nearly all the mate-

rials necessary for their growth, and that these accumulations are to be viewed as water and air altered by the powers of vegetation? It may be answered, that vegetables will not thrive in water and air alone. This is no doubt the fact with respect to the more perfect vegetables; but those of the lower orders, as the Cryptogamia, of which alpine peat is principally composed, we know will grow and flourish in water. Others will object to this opinion, that vegetables do not possess the power of converting water into carbon, metallic, and earthy matters. The late experiments of Schraeder*, however, have shewn, what was long ago conjectured by Sir Isaac Newton and other philosophers, and even asserted by late experimentalists, that plants raised in distilled water af-

* Zwei Preisschriften über die eigentliche beschaffenheit und erzeugung der erdigen bestandtheile in den einheimischen Getraidearten. Berlin, 1800. f. 17. 18.

ford a vastly greater proportion of carbon, metallic, and earthy matters, than existed in the feeds from which they were raised, consequently that these materials must have been formed from the water, or the water and air combined. The facts ascertained by Schraeder receive confirmation from geognosie.



NOTES

AND

ILLUSTRATIONS.

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NOTES

AND

ILLUSTRATIONS.

A.

THE descriptions of the physiognomy of the earth's surface, as detailed in geographical works, in particular, what has a reference to the grouping of mountains, are often indistinct and imperfect. I shall, in proof of this, mention a few instances drawn from the descriptions of several modern geographers. By them Bohemia is described as a flat coun-
On mountain groupes.

try, furrounded by a range of mountains; Norway is said to be separated from Sweden by a long and elevated chain of mountains; the Pyrenean mountains that divide France and Spain, the Uralian mountains that are interposed between Siberia and Russia, and the mighty and long extended Altain chain which bounds Siberia on the south and west, are also described as chains of mountains. By a chain of mountains, however, we understand in common language a collection of single mountains linked together in a lengthened form. The mighty and extensive elevations we have just mentioned do not correspond with this definition, because they are composed of many such chains, which are arranged in a determinate order; we must therefore give them another denomination, and one which shall convey no erroneous meaning. If we examine them particularly we shall find that the mountain chains of which they are composed,

are not irregularly distributed, but are usually arranged into groupes, and that each groupe has a central or more elevated chain towards which a number of lateral chains tend. We must therefore denominate the Pyrenees, Uralian mountains, great southern chain of Scotland, &c. *chains of mountain groupes*, not chains of mountains.

B.

Almost every mountain has a *foot*, *ac-* Parts of which a mountain is composed. *clivity*, and *summit*. By the *foot* we understand the lowest and flattest part of a mountain. It sometimes extends to a considerable distance, and then it rises under an angle of 8° or 10° ; when it is less extensive, or has a smaller base, it rises under a somewhat greater angle, but never greatly exceeds 10° . The mountains in wide valleys have generally a considerable foot, but those in narrow valleys are less in extent. Sometimes, as

in mountains having a *mural ascent*, there is no foot.

The *acclivity* or *ascent*. By this we understand the space contained between the foot and the summit of a mountain. It is usually the steepest and most considerable part of it. Its inclination is more or less than 30° , and on this depends the greater or lesser covering of soil. Upon an acclivity of 30° and upwards we find a good cover of soil; at 45° , however, the acclivity is too great to admit of a firm covering, so that on it the soil is loose and much extended, yet still sufficiently coherent to admit of the growth of trees. Sometimes the acclivity is perpendicular, forming mural precipices, and it is either mural on one, two, or on all sides, or on single spots. Granite, porphyry, and sandstone afford instances of such acclivities.

Summit. This is usually the smallest part of a mountain, and its inclination is

generally less considerable than that of the acclivity. There occurs, however, exceptions to this; thus, there are summits that rise more rapidly than the acclivity, and these are usually very high, and almost of equal height with it, and are completely naked. Such lofty and precipitous summits are, in Switzerland, called peaks. The summit varies considerably in its shape; it is either tabular, round-backed, or obtuse, acute, or short-conical. Generally the shape of the mountain is characteristic of the rock of which it is composed. Thus gneiss and transition rocks form flat or round-backed summits, clay slate conical summits, and basalt and some other rocks short and obtuse conical summits. Granite and limestone often present extremely sharp pointed summits, or peaks.

C.

River districts.

The surface of the earth is, by rivers and their lateral streams, divided into great portions, which are by hydrographers termed *river districts*. These districts are generally very wide and flat troughs or concavities, in which the main river occupies the lower, and its exit from the concavity the lowest point of the district. Thus the river Annan occupies the lower part of the district of Annandale, and at its exit into the Solway frith the lowest point. In good maps we can trace out these districts, by drawing lines along the points where the small rivers and rivulets of the district take their rise, and thus we obtain the boundary of the river district. Hydrographical maps of this kind afford to the geognost opportunities of making many interesting observations.

D.

In the Allgemeine Literatur Zeitung, ^{Valleys of the moon.} ft. 90, the circular valleys through which the Danube flows are not unaptly compared with the spots on the surface of the moon. Thus Bavaria and Swabia are compared with the Mare Crisium, Austria with Newton, Bohemia with Plato, and Hungary with the Mare Imbrium. Schroeter, in his admirable work entitled *Selenographische Fragmente*, gives us a very particular account of the disposition of the mountains and mountain ranges on the surface of the moon; but he makes a very improbable conjecture when he says, that the circular spots are to be considered as craters of immense volcanos.

E.

On forma-
tions.

All those rocks which have been formed at the same period, and which agree in geognostic characters and relations, are said to belong to the same formation. Thus wacke, basalt, greenstone, and porphyry slate occur together, and in similar geognostic relations, and hence are considered to have been formed at the same epocha, and consequently to belong to the same formation. But there are instances of the repetition of the same mineral at different epochas, and in formations of different ages and kinds. In such a series all its members have general points of agreement, and the individual ones bear characters, not only expressive of the period of their deposition, but also of the circumstances under which they were formed. Such a series or formation is by Werner denominated a *principal formation suite*. Examples of it

we have in limestone, trap, and slate. To illustrate this highly interesting observation, I shall mention the members of the limestone and trap suites.

The first member of the limestone for-
mation suite is the white granular lime-
stone, which occurs in gneiss, mica slate,
and clay slate. This limestone has large-
grained distinct concretions, but in the
newest clay slate the concretions become
more minute, and it even approaches to
compact. The transition rocks contain
the second member of the series, the
variegated limestone, which has less
translucidity than the preceeding, but
more than the following members of
the series, and shews the first traces of
petrifications. The following or floetz
rocks contain the third member of the
series, the grey floetz limestone, which
is scarcely translucent on the edges, and
is full of petrifications. It has some
resemblance to the limestone of the
transition period, but only the most

Limestone
formation
suite.

distant to that of the primitive. How great is the difference between the granular translucent primitive limestone and the dull earthy and nearly opaque floetz limestone ! and yet both are members of a series of chemical formations, which are still not the most distant. Chalk is the newest formation of this period ; it connects the foregoing members, which have been deposited from the ocean, with the calc tuff, the lowest link of this formation suite (if we do not include the coral rocks which are daily forming) which has been formed on the land. We have thus a complete series from the earliest to the latest period, in which we observe a gradual disappearance of the crystalline, and increase of the earthy aspect, corresponding with the relative age of the different members of the suite, and the state of the solvent, from which they were precipitated.

Trap formation suite.

In the trap suite although the different members have a great resemblance to each

other, yet they all bear distinct marks of the period of their formation. The oldest or primitive greenstone is highly crystalline, the newer or transition is less crystalline, and in the newest or floetz-trap it approaches to earthy, as shewn in basalt, and more particularly wacke, as the lowest link, or furthest removed from the highly crystalline primitive greenstone.

F.

In describing a rock mass, or mountain, we must be careful not to be too micrological in our observations, otherwise we shall fail in communicating a distinct picture of it. All that is necessary in such investigations is, first, to ascertain the formation to which it belongs; secondly, whether it is stratified, disposed in beds, in lying or erect masses; thirdly, the characters of the rock, and those that appear to be peculiar to it, or

Method to be followed in investigating and describing a rock mass or mountain.

which distinguish it from rocks of the same species. By the first we ascertain its age in relation to the other masses of which the crust of the earth is composed; by the second its structure in the great; and by the third its structure in the small, or in hand specimens, and the characters that distinguish it from other rocks. Any thing further, any attempt at describing every variety of the aspect of a rock, is useless, and those who persist in such unnecessary discriminations are not acquainted with the method of conducting geognostical investigations.

G.

Instances of
loosely ag-
gregated
quartz.

Quartz, in a similar state of aggregation, has been observed in mineral veins in the Harz. Voight, on descending into the mine called Louisa Christiana at Lauterberg in the Harz, found that nearly the whole of the vein, which was about

nine fathoms wide, was filled with quartz in the state of sand. In this loosely aggregated quartz, tuberosc-shaped pieces of copper ore are interspersed, and the miners only use picks and shovels to separate the ore from its vein-stone. *Vide* Voight's *Kleine Schriften*, b. 1. f. 168. Lazius in his description of the Harz, mentions similar appearances.

This loose state of aggregation is probably its original one, and not caused by alteration since deposition.

H.

To shew how favourable the transition rocks, of which so great a part of this county is composed, are for the occurrence of ores, I shall mention a few instances of their metalliferous nature in other countries.

Transition
rocks favourable for ores.

The Harz, which is one of the most considerable mining countries in Europe, contains a great extent of transition rocks, and in these the richest mineral repositories of that country are situated. Thus at Andreasberg there are many extensive veins of silver ore in transition slate; at Clausthal there are veins from two to fourteen fathoms wide, which are composed of lead glance, black and brown blende, iron and copper pyrites, sparry iron stone, white silver ore, red silver ore, brittle silver ore, fahl ore, and tinder ore, and the vein stones are calc-spar, quartz, and lamellar heavy spar.

The richness of these veins is astonishing. Friesleben observed the Dorothea vein in the district of Clausthal eight fathoms and a half wide, and composed of pure lead glance, so that, as he observes, it appeared like a quarry of ore. Friesleben's Harz. b. 2. f. 159.

At Verespatack in Transylvania, gold is found in small veins that traverse grey wacke. These veins are only about an inch in width, but from their great number they are worked with considerable profit.

In Piedmont and in Westerwald there are also rich silver mines in transition rocks.

I.

The occurrence of sandstone in globular or spherical distinct concretions has been seldom observed; the only instances I am acquainted with are the following: On the occurrence of sandstone in globular distinct concretions. In the island of Skye, near the harbour of Portree, the sandstone is composed of very large globular distinct concretions. Mineralogy of the Scottish isles, vol. 2. p. 87. 88.

Reufs, in his Mineralogical Geography of Bohemia, describes, in the following

words, a similar appearance : “ The sand-
“ stone is ochre yellow, yellowish brown,
“ and sometimes brownish black. Its
“ basis or cement is sometimes clayey,
“ particularly the ochre yellow ; some-
“ times it is *iron-shot*, as is the case with
“ the brownish black, and in such varie-
“ ties the basis is a more or less disinte-
“ grated iron ochre, which connects the
“ different angular and rounded quartz
“ grains. It appears to lie in pretty (from
“ two to four feet) thick horizontal beds ;
“ on a more near examination, however,
“ we find that every bed is composed of
“ compressed sandstone balls lying close
“ together, and that these balls are again
“ composed of *thick and concentric lamellar*
“ *distinct concretions*. The structure of
“ these concretions is rendered more
“ distinct by their being alternately
“ composed of ochre yellow, fine grained
“ clayey sandstone, and of yellowish
“ brown and brownish black iron-shot,
“ coarse grained sandstone (or rather
“ breccia). The long continued action

“ of the atmosphere on these sandstone
“ balls, gradually disintegrates the clayey
“ sandstone, which, on account of its
“ friability is the more easily effected.
“ The rain washes it out, and then only
“ the somewhat thinner lamellæ of the
“ iron-shot sandstone remain behind. By
“ this means the sandstone acquires a
“ large vesicular corroded aspect, thus pre-
“ senting complete oval shaped, and
“ sometimes irregular vesicles. The sur-
“ face of the remaining iron-shot sand-
“ stone becomes brick red and reddish
“ brown, owing to the increased oxida-
“ tion of its iron.” Reufs’s Mineralo-
gische Geographie von Böhmen, b. 2.
f. 46. 47.

Observations.

The occurrence of sandstone in distinct concretions shews that a very considerable portion of the matter of which it is composed was, at the time of its formation, in a sufficiently minutely divided state, to allow it to form masses having a some-

what regular shape. Flinty sandstone affords another still more striking instance of the occurrence of sandstone with a chemical basis. At Salisbury crags there are fine examples of this kind of sandstone.

K.

No subject in geognosie is more highly interesting than the history and description of petrifications. It makes us acquainted with the various organized beings that existed during the different periods of the earth's formation; it points out the gradual increase and dispersion of animals and vegetables; it discloses to the botanist and zoologist whole myriads of animals and vegetables, that probably no longer exist on our earth; and it affords to the geognost very elegant illustrations respecting the different ages of the mineral

Importance
of the know-
ledge of pe-
trifications.

masses, of which the crust of the earth is composed.

Very long ago, petrifications attracted the attention of naturalists, and first gave rise to the forming collections of minerals, and to the more zealous study of geognosie. At first they were viewed only as proofs of the tremendous deluge described by Moses, and for a long time naturalists did not venture to consider them as capable of affording any other explanations, respecting the history of changes which the earth has experienced. The rocks in which they were found, and the determination of their species were little attended to, the principal object of those investigators being to discover them in every rock, with the view of thus, from natural appearances, proving the universality of the deluge. A more careful examination, however, discovered that the greater number existed in rocks whose origin is anterior still to that of the universal deluge.

Almost all the older writers as Lugd, Woodward, Mylius, Scheuchzer, Mendez da Costa, and Volkmann, considered vegetable impressions as having been formed at the time of the flood. Very early, however, Leibnitz in his *Histoire des Sciences* for 1706, p. 11. mentions as a very extraordinary circumstance the occurrence of the impressions of Indian plants in German rocks; and Schulze in his *Beschreibung der bei Zwickau gefundenen Kräuter abdrücke*, f. 47. in the first volume of the *Neue Gesellschaftlichen Erzählungen* for the year 1758, contrasts the vegetable impressions found in the coal field of Zwickau with the figures of ferns drawn by Pluckenet and Plumier, but he does not deduce any conclusions from these comparisons. Mylius in his *Memorabilia Saxonix Subterraneæ*, p. 20, conjectures that some of these impressions

Jussieu's opinion. may belong to exotic plants. Jussieu in his valuable memoir, entitled *Examen des Causes des Impressions des Plantes*

marquées sur certaines pierres des environs de Saint Chaumont, &c. at page 866, in the History of the Academy of Sciences for 1718, says expressly that the originals of these plants must exist either in the East or West Indies, because they have the greatest resemblance to the ferns and marsh plants of those countries, or *they no longer exist on the surface of the earth*. Many succeeding naturalists have adopted the idea that the greater number of vegetable impressions belong to species now extinct, and Werner, whose authority in such cases is superior to that of all others, long ago concluded from his observations *that all the impressions found in the older formations belong to vegetables now extinct, and which flourished and died in the countries where we now find them*. ^{Werner's opinion.}

I shall not here enter into any illustration of this opinion, but shall earnestly recommend the examination of the numerous vegetable impressions which are found in the coal fields of Scotland to

the careful study of botanists. To assist those who are inclined to enter on this wide field of highly interesting investigation, I subjoin a list of authors who have treated of vegetable impressions.

Catalogue of
authors who
have treated
on vegetable
petrifications.

1. The History of the Academy of Sciences for 1703, 1706, 1708, and 1716; also for 1692, 1666, and 1699.

2. Acta Eruditorum, from 1710 to 1723.

3. Naturgeschichte der Nassawischen Lander von Cammerath Habel.

4. Weimarische Magazin.

5. Herbarium Diluvianum.

6. Paulus Gerardus Moehring, Phytolithus Zeæ Linnæi in schisto nigro duriusculo. Act. Acad. Nat. Curios, tom. 8, p. 448, and 450.

7. Knorr's Lapidés Diluvii Testes, folio.

8. Jean Gottlob Lehman sur des fleurs de l'Asier Montanus ou Pyrenaique. precoce, a fleurs bleues, et a feuilles de faule, empreintes sur l'Ardoise. Hist de l'Acad. de Berlin. 1756, p. 127. 144.

9. Emanuel Mendes da Costa, Account of the Impression of Plants on the Slates of Coals. Philosophical Transactions, vol. 50. p. 228. 235.

10. Geoffroy, Memoire sur quelques Empreintes Fossiles, Journal de Physique, tom. 28. p. 269. 271.

11. Tingry's Observations on some extraneous Fossils of Switzerland. Lin. Transf. vol 1.

12. Jean Guillaume Bruguiere. Sur les Mines de Charbon des Montagnes de Cevennes, et sur la double empreinte des Fougères qu' on trouve dans leur schistes. Journ. d'Hist. Nat. t. 1.

13. Notice sur des Plantes Fossiles de diverses especes qu'on trouve dans les couches fossiles d'un schiste marneux recouvert par des laves, dans les environs, &c. par Fugas St. Fond. Annales. Mus. Nat. p. 389.

14. Abhandlung über die Kräuter abdrücke in Schieferthon Sandstein, &c. von von Schlotheim. Hoff. Mag. b. 1. f. 76.

15. Ure's History of Rutherglen and Kilbride.

16. Lithophylacii Britannici, &c.

17. James Parson's Account of some Fossil Fruits and other Bodies found in the Isle of Shepey.

18. Phil. Transact. vol. 50. p. 396. 407.

19. Parkinson's organic Remains of a former World, quarto. It is to be regretted that Mr. Parkinson has given so limited an account of the numerous vegetable impressions of the coal formations of Britain.

L.

On the distinction between strata seams and accidental rents.

In making observations with the view of determining the presence or absence of stratification, we must be careful to distinguish between the *seams of the strata* and *accidental rents*. The following observations will assist those engaged in such investigations :

1. Strata are always parallel with the slaty structure of the stone. In certain

porphyritic granites the crystals of felspar appear to lay parallel with the strata; the latter character, however, is by no means so decisive as the former.

2. Strata can only be formed by parallel seams which have the same direction and extent through the mountain mass. Where parallel rents occur in different directions in the same species of rock, as in granite, sandstone, limestone, &c. it is evident that they are to be considered as accidental.

3. The seams of tabular distinct concretions, which are often of considerable extent, must not be confounded with strata seams, because their extent is not so considerable, and in each groupe of concretions the direction is different. A good example of these seams is to be seen in the basalt of the Castle rock of Edinburgh.

4. Where parallel rents have a different direction from the flaty structure of the stone they are certainly accidental. Inattention to this circumstance has led several mineralogists into error. I observed a striking instance of these rents in a quarry of gneifs, in the forest of Tharand in upper Saxony. The gneifs, at first sight, appeared to be disposed in vertical strata, and as such it was viewed by De Luc; on a closer examination however, the apparently vertical seams proved to be merely accidental parallel rents perpendicular to the flaty structure of the stone; therefore the strata were horizontal not vertical.

5. Beds are always parallel with the strata; these, therefore, point out the direction of the strata.

6. Although the flaty structure points out to us the direction which the strata must have, it does not follow that a rock having a flaty structure is stratified.

7. In sandstone, limestone, and salt, regular and very extensive stripes are sometimes observed, which have been confounded with true strata seams. An attentive examination, however, always discovers them traversing the real seams of stratification. Von Buch, in his description of Landeck *, and geognostical observations made in Italy and Germany †; Friesleben, in his observations on Thuringia ‡; and Sir James Hall, in the theory of the earth, published by the late Dr. Hutton of Edinburgh ||, describe striking instances of stripes resembling stratification. The following is the explanation of this phenomenon, as given by Von Buch. “Wahrscheinlich liegt
“die Ursache in einer grossen Bewegung

* Versuch einer mineralogischen Beschreibung von Landeck, 4to.

† Geognostische Beobachtungen auf Reisen durch Deutschland und Italien.

‡ Geogn. Beobachtungen in Thüringen. Lempe. Mag. der Bergb. x. 93.

|| Hutton's Theory of the Earth, vol. 1.

“ der sich bildenden masse, theils aus all-
 “ gemeinen ursachen, theils weil sie in
 “ mehrere bewegung zugleich mitgetheilt
 “ werden könnte; durch welche sie
 “ ungleichförmig abgesetzt und genöthi-
 “ get wurde, mulden und hügel zu bilden;
 “ und so diese sonderbaren zeichnungen
 “ hervorzubringen.” Von Buch. Reisen.
 1. b. f. 161.

M.

Different
 iron stone
 formations.

The formations of iron are, according to Werner, more numerous than those of any other metal, and are almost of every age. The magnetic iron-stone found in primitive mountains, and particularly in limestone strata, is the most ancient formation of this metal with which we are acquainted; the red iron-stone formation is much newer; that of the brown and sparry iron-stone still of a more recent date; and the clay iron-stone is newer than any of the preceding. The mag-

netic iron sand, and the clay iron-stone which occurs in the newest floetz-trap is of a very late formation ; but the newest of all is that which is daily forming on the surface of the earth, and which we are acquainted with under the names of bog, marsh, and meadow iron ore.

N.

Slaty glance coal, or coal blende, was considered to be exclusively confined to the primitive rocks, until I discovered it in the independent coal formation, in the island of Arran. Since that time it has been observed by Meuder in the independent coal formation, near the village of Brandau in the Saatzer circle in Bohemia. The following is the interesting notice he has communicated on this subject :

On the occurrence of glance coal in the independent coal formation.

“ Es ergiebt sich aus dem obigen, das
 “ die kohlenblende nicht den urgebirgen

“ allein eigen ist, wie man bisher glaubte,
“ sondern das sie auch den Flötzgebirgen
“ zugehört. Nur vor einigen monaten
“ überzeugte ich mich mit eigenen augen
“ von der wirklichkeit dieser thatsache :
“ ungefähr eine viertel stunde sudwestlich
“ von dem in Böhmen in Saatzer Kreise,
“ hart an der sächsischen grenze gelegen
“ nen dorfe Brandau befindet sich ein
“ kleines steinkohlen gebirge an und auf
“ das dasige gneiss gebirge halbmulden
“ förmig gelagert. Es besteht aus einem
“ sandsteine, welcher die steinkohlen-
“ gebirge caractirisirt, und der, wie
“ mir es schien, zunächst auf dem gneus
“ liegt ; ferner aus schieferthon, der un-
“ gemein schöne pflanzenabdrücke en-
“ thält und in den sandstein vollkommen
“ übergeht, aus brandschiefer und aus
“ mehrern schwachen thoneisenstein-
“ flötzen. Mit diesen flötzen von schief-
“ erthon, brandschiefer, u. s. f. wechseln
“ nun ganz schwache höchstens 2 zoll
“ starke flötze oder lagen von der aus-
“ gezeichnetsten *koblblende* ab ; öfters ist

“ sie blofs eingesprenzt und angeflogen.”

Jameson's Mineralogische Reisen durch die Schottischen Inseln, &c. übersetzt von H. W. Meuder. f. 33.

O.

Graphite*, or black lead, has been hitherto considered as exclusively confined to the primitive mountains. In Germany it is found in gneiss, mica slate, and clay slate, usually in beds, and sometimes disseminated; in Greenland it occurs along with quartz and adularia; at Keswick in Cumberland it occurs in imbedded masses in a rock which is said to be clay slate; I suspect, however, from the general nature of the rocks of that country, and from

New graphite formation.

* As the name black lead conveys an erroneous idea of the nature of the substance, Werner very properly abolished it, and substituted in its place that of *graphite*. This term begins now to be used in England, and for many years it has been universally adopted in Germany.

specimens I have had an opportunity of examining, that it is transition slate or fine-grained grey wacke. The graphite I am now to give a short account of, on the contrary belongs to the floetz rocks.

The county of Ayr, in which this formation occurs, as far as I have had an opportunity of examining it, appears to be a large semicircular valley, bounded on the south, east, and north, by mountains of considerable height. These mountains where they border on Kirkcudbrightshire, Dumfriesshire, and part of Lanarkshire, are composed of transition rocks, which are frequently covered with portions of the newest floetz-trap formation. The lower and flat part of the valley is principally occupied by the independent coal formation, and the newest floetz-trap formation. The graphite which I am now to describe is about four miles from New Cumnock, and is situated in the lower part of the county, but not far distant from the transition mountains. The beds

of rock are well exposed, and the following is the order in which they occur, beginning with the uppermost. I must previously remark, however, that there are two sections of the formation, one which is called the mine, where a gallery has been driven to procure graphite, and another at a little distance, but as they differ from each other only in the number of beds, I shall describe them as one.

1. Thick bed of greyish white and yellowish white coloured sandstone, which is rather of a loose consistence, and contains much intermixed mica. In some parts it presents globular and spherical distinct concretions, like the sandstone in the coal field of Byreburn. The upper part of the bed appears to be flaty, or rather in plates.

2. Immediately under the sandstone is a bed of slate clay, which is from ten to twelve feet thick. In some parts it passes

into a flinty fossil that appears verging on flint, or flinty slate.

3. The next is a bed of greenstone, which presents globular distinct concretions. In it I observed masses of graphite.

4. Immediately below this bed of greenstone is a bed of slate clay about twelve feet thick, which is also in some places flinty.

5. Is a bed of greenstone in globular distinct concretions, from three to ten inches thick.

6. Bed of *columnar glance coal* from three to six feet thick, in which the columns are arranged in rows like basalt. Intermixed, and often forming a great portion of this bed, we find *the graphite* *,

* It is worthy of remark that conchoidal, flaty, and columnar glance coal, natural mineral charcoal,

which is either compact, scaly, or *columnar* *. I observed masses of greenstone imbedded in the coal and graphite, but whether they are to be considered as fragments, or as of cotemporaneous formation with them, I cannot with certainty determine. The latter supposition is the most probable.

7. Immediately under this remarkable bed of graphite and glance coal we meet with another bed of greenstone.

8. Under the preceeding there is a bed of the rock resembling flinty slate, which is from ten to fourteen feet thick.

and graphite, (probably also diamond) the only species of unbituminated carbonaceous minerals hitherto known, occur in rocks connected with the floetz-trap formation.

* A description of this new subspecies of graphite will be given in the second volume of my System of Mineralogy.

9. The lowest bed visible is of sandstone resembling N. 1. in colour, solidity, structure, and ingredients.

On first examination, and before I had convinced myself of the existence of greenstone in the independent coal formation, I suspected that these beds belonged to the floetz-trap formation. My friend, the late Dr. Mitchell, to whom I communicated a short description of this highly interesting spot, gave it as his opinion that it belonged to the independent coal formation. On an attentive and repeated examination of this section, I found it, as Dr. Mitchell had conjectured, to be a part of the neighbouring coal formation*.

* Mr. Taylor, an experienced miner, informed me, that in sinking for coal in the neighbouring coal field, a bed of greenstone was cut through.

P.

In several places in the low part of the county pretty large loose blocks of water-worn syenite are to be observed lying on the surface of the coal formation. Water-worn masses of the same rock occur in the reddish brown coloured sandstone conglomerate, and the floetz-trap rocks, a fact which affords a sufficient explanation of the situation of the loose masses.

On the occurrence of loose masses of syenite in the lower parts of the county.

In the Alps, of which the celebrated Saussure has given so interesting, animated, and delightful a description, many masses of rock are found, far distant from their original situation. To explain this phenomenon many hypotheses have been contrived in the closet, which bear sufficient marks of the ignorance and presumption of their fabricators. Others, and among these the illustrious Saussure himself, have, after painful and minute examination of the Alps and other similarly con-

structed countries, endeavoured, but unsuccessfully, to unravel a difficulty which is easily solved by the *new Geognosie*.

P. a.

On the distinction between strata and beds.

Much confusion has arisen from the incorrect use of the terms *stratum* and *bed*; the following appears to be the sense in which they are employed by the greater number of geognosts, and is the meaning I have annexed to them in this work, and in my System of Mineralogy.

When a mountain composed of one species of rock is divided by means of parallel seams into masses, whose length and breadth are greater than their thickness, or into what may be called tabular masses, which extend through the whole mountain, it is said to be stratified, and the individual masses are termed strata. Of this kind of structure we have in-

stances in granite, limestone, clay slate, mica slate, &c. But if the mountain, or mountain mass, consist of an alternation of different rocks, as of clay slate and greenstone, or of gneiss and limestone, it is said to be composed of beds.

Q.

It has been asserted with considerable confidence by several mineralogists that reddish brown coloured sandstone, is never to be found in the coal formation. That this position is false is evident from the following facts :

On the occurrence of red sandstone in the coal formation,

1. In lower Silesia, as already mentioned, nearly the whole of the coal field is composed of reddish brown and cochineal coloured sandstone, with which great beds of coal alternate.

2. In the coal field of Mid Lothian we have the following instances of similar

coloured sandstone occurring in the coal formation :

a. In Dryden water, near Loanhead, there are several beds of reddish brown coloured sandstone, accompanied by similar coloured iron-stone, in the coal formation.

b. Near Mr. Cameron's paper mills on the banks of the Esk, there are thick beds of reddish coloured sandstone that evidently belong to the coal formation, and the same rock continues in the direction of the river, forming the picturesque cliffs of Hawthornden and Roslin, and extends even to Auchendinny bridge.

c. Immediately behind the manse of Collington there is a beautiful section of the coal field. The strata are semicircular, and have their convexities uppermost, or form what is called a *saddle*; they are of a reddish brown colour, and

alternate with layers of greyish black coloured slate clay, and reddish brown coloured clay iron-stone. On each extremity of the saddle rest the more common rocks, *viz.* grey coloured sandstone, globular clay iron-stone, &c.

d. The rock on which Craig Millar castle is situated belongs to the coal formation of Mid Lothian. It is composed of horizontal beds of greyish and reddish coloured sandstone, that alternate with thin beds of reddish coloured slate clay and limestone conglomerate.

e. The hill called Salisbury craigs belongs to the coal formation, and in it we observe repeated alternations of reddish coloured sandstone, clay iron-stone, slate clay, and limestone conglomerate.

R.

On green-
stone.

1. English mineralogists continue to use the Swedish word *grunsten*, or *gronsten*, and the German *grünstein*, in place of the English term *greenstone*; but without giving any reason for this preference.

2. It has been objected to the name *greenstone*, that it is borrowed from a very fugitive and insignificant character; and besides, that stones answering in other respects to the character *greenstone*, have sometimes a faint or hardly perceptible trace of green. It would extend this note to a great length were I to enter into the discussion of the merits of colour as a distinguishing character of minerals. I can at present only say, that the degree of importance annexed to it by Werner is a sufficient proof of its excellence. That *greenstone* has not always a green

colour cannot be denied, but this circumstance must not be urged as an objection to the name, as it is not asserted that this rock has always a green colour, the name only intimating that this colour is the most striking feature in its external aspect, and which always occurs in truly characteristic specimens.

S.

The very interesting fact of the occurrence of greenstone in the coal formation has not before been noticed by any mineralogist. I shall therefore take this opportunity of mentioning a few instances of it I have had an opportunity of examining. On my return from Freyberg to Scotland, the first object that attracted my attention was the interesting coal field in the neighbourhood of Edinburgh. I traversed it in different directions, and the result of my first observations render-

On the occurrence of beds of greenstone in the coal formation.

ed it rather probable that Salisbury craigs, Arthur seat, Craig Millar, cliffs at Hawthornden, Craig Lockhart, and summit of the Pentland hills, belonged to the floetz-trap, and consequently were of posterior formation to the coal. I had, however, examined these appearances too slightly to enable me to judge decisively on so important and intricate a point; and besides, some circumstances which I shall now mention excited a suspicion that several of these appearances might be of different ages, or belong to different formations. The strata and beds of Salisbury craigs, Craigmillar and Hawthornden were too numerous, and often too much inclined to be referred to the floetz-trap formation; while on the other hand, the summit of Arthur seat, and Craig Lockhart, were unstratified, or when the stratification could be observed was very thick and horizontal; characters that strongly indicated a different formation, and one that could be

referred to the floetz-trap. I continued my researches, with the view of ascertaining this point, when a careful examination confirmed my suspicions, and I found that Salisbury craigs, Craigmillar, and the cliffs of Hawthornden, belonged to the coal formation ; but the summit of Arthur seat, and Craig Lockhart, to the newest floetz-trap formation.

The most interesting observation which I made during this investigation was that of beds of greenstone in the coal formation ; an appearance so unexpected that I was for some time doubtful whether or not the whole series of strata that accompanied these beds should not be referred to the floetz-trap formation. The following are some of the instances of this fact which I had an opportunity of examining :

1. *Salisbury craigs.* The lowest part visible of this hill is sandstone, which is covered by a bed of porphyritic green-

stone; over these beds there lie, in conformable disposition *, many strata of reddish brown coloured slate clay, similarly coloured clay ironstone, limestone, and sandstone. This great mass of strata and beds supports a bed of greenstone about eighty feet thick, which forms what is called Salisbury craigs. Over it there is disposed a number of thin beds of greenish coloured slate clay, reddish coloured clay ironstone, which sometimes approaches to jasper, and thick beds of reddish brown coloured sandstone. To these succeed beds of porphyritic greenstone, which in some places passes into green porphyry †. Over these much inclined strata and beds, that all evidently belong to the *coal formation*, there lie in

* Williams, in his Mineral Kingdom, informs us that whinstone beds occur in the coal mines of Borrowdonne's and Gilmerton. Probably greenstone?

† This green porphyry is in some specimens not greatly inferior to certain varieties of the antique green porphyry.

overlying † disposition, first a great horizontal mass of trap-breccia, and then two beds of basalt, the uppermost of which forms the summit of Arthur seat; these from their situation and characters are to be referred to the *newest floetz-trap formation*.

2. *Section of the coal formation below Caroline park.* About a mile west from Newhaven, immediately below the walls of Caroline park, there are a number of beds well exposed by the action of the sea. They are slate clay, flat spherical clay iron-stone, a black flinty † fossil resembling flinty slate, greyish coloured sandstone, and these alternate repeatedly with beds of greenstone. The varieties of greenstone which these beds present are de-

* When horizontal beds or strata rest on those which are much inclined, I express their situation by the term *overlying*. Figure 2. in plate 4. represents an instance of this kind of stratification.

† This fossil is frequently found in the coal formation. Although very unlike basalt, it has often been confounded with it.

erving of notice. Some of the beds are almost entirely composed of compact felspar, and then the greenstone has a smoky or ash grey colour; in other beds we can observe the gradation from greyish white to greenish black, by the increase of the quantity of hornblende.

3. *Section on the Collington road.* Half way between Edinburgh and the village of Collington, on the estate of Dr. Monro, is a quarry in which there is a bed of greenstone about four feet thick, accompanied by slate clay, soft greyish white sandstone, &c.

4. *At Bell's mills* in the neighbourhood of Edinburgh, there is a bed of greenstone about eight feet thick which rests on slate clay, and is covered by slate clay, greyish white sandstone, containing vegetable impressions, all belonging to the coal formation *.

* On digging a foundation for the houses in Lothian-street, a pretty thick bed of greenstone was

T.

The usual directions which are given ^{Observations} for searching for coal are not sufficiently ^{on searching} for coal. complete. The following statement of the cases that may occur in this investigation will, I trust, be found useful:

Case 1. Suppose we have examined a tract of country which we find to be composed of transition rocks, and rocks belonging to the newest floetz-trap formation; are we there to bore or sink shafts, with the view of discovering coal? If we have ascertained that the floetz-trap rocks repose immediately on the transition rocks, then the scarcity of fuel must be very great, or the appearances very promising, before expensive trials should be attempted; because, in the floetz-trap formation we seldom find

observed in strata resembling those of Salisbury
craigs.

more than one bed of coal, and the expence of mining is very great, owing to the excessive hardness of the superincumbent rocks. But if we entertain a suspicion that the independent coal formation is interposed between the transition and floetz-trap rocks, we should continue our researches into the neighbouring districts, where, if we discover the independent coal formation, and can trace it so as to demonstrate that it lies under the floetz-trap rocks of the district we have examined, we should then make borings, or sink shafts, with the view of reaching the coal formation. This is illustrated by plate 1.

Case 2. In districts where the independent coal formation exists, and where the *outgoing* of the coal is not to be observed, the borings and sinkings must be conducted in the usual manner. *Vid. William's Mineral Kingdom. Kirwan's Geological Essays. Dr. Walker's Letter to*

General Dirom. Mineralogy of the Scottish Isles.

Case 3. If the district we have examined is composed of reddish coloured sandstone, accompanied with beds of copper-slate, foliated gyps, and limestone, we must not make any attempts to bore or sink for coal, as no considerable beds of coal exist in this formation.

Case 4. If the district we have examined is composed of sandstone which has a variegated coloured aspect, and contains nests of clay, and is accompanied with fibrous gyps, sandstone slate, and roestone, we must not make any trials for coal.

Case 5. If the district is composed of fine white coloured architectonic sandstone, but contains no subordinate layers, as sandstone slate, gyps, roestone, clay iron-stone, slate-clay, bituminous shale, or limestone, we must not make trials for

coal, as this sandstone formation never contains any beds worthy of notice.

Case 6. Suppose a shaft is sunk in the reddish coloured sandstone mentioned in Case 3, and that then a gallery is driven in a horizontal direction across these strata, with the view of discovering coal, and that beds of coal are discovered, we must not believe that these beds lie in the reddish coloured sandstone, and that therefore we are warranted to make trials for it in other quarters of this red sandstone district, because we shall, on an attentive examination, find that we have passed into the coal formation. Errors of this kind have given rise to the opinion that coal is found in the old red sandstone, and has been the cause of many expensive trials having been made. This case is explained by Plate 2.

Case 7. Suppose we have discovered beds of flaty glance-coal (coal blende) in transition or grey wacke slate, we must

not from this conclude that black or common coal * is to be found, and make trials with the view of discovering it, as none occur in these rocks.

Case 8. If in the newer clay slate, flaty glance coal (coal blende) is found, we must not consider it as indicating common or black coal, and should not therefore make any trials in such situations.

Case 9. Suppose we have discovered the independent coal formation, and have sunk shafts into it to a considerable depth, without discovering workable beds of coal, we must be cautious not to increase the expence unnecessarily by continuing the workings beyond the coal field on its sides or bottom. This is illustrated by Plate 3.

* Werner divides coal into two species, *a.* brown coal, and *b.* black coal. The black coal includes all the subspecies of coal which are found in the independent coal formation in Great Britain &c.

U.

It was Werner who discovered the transition of clay to wacke and basalt. The following extract from his memoir on that subject, which is too little known in this country, is worthy of the particular attention of every geognost :

“ L’Observation, toute-a-fait inatten-
“ due, que j’ai faite l’été dernier au
“ mont *Schiebengberg*, sur la rapport du
“ basalt a la roche que se trouve au-des-
“ sous, me parait devoir etre extemement
“ interessante aux yeux de tous les geo-
“ gnostes sans prevention ; sur-tout dans
“ ce moment ou la discussion sur la na-
“ ture et sur l’origine du basalte vient
“ de se rallumer de nouveau. Deja de-
“ puis long-tems, en passant aupres ce
“ mont, j’avais vu de loin un monceau de
“ terre blanche, qui etait presque sur sa
“ sommité ; j’avais, dans les tems, de-
“ mandé ce que c’était, et l’on m’avait

“ repondu que, dans cet endroit, il y
“ avait une mine de fable, dont les habi-
“ tans se servaient pour la batisse de leurs
“ edifices. Ayant depuis reflechi, com-
“ bien une mine de fable sur le haut
“ d’une montagne basaltique etait un
“ phenomene singulier, je resolus de
“ l’aller voir de pres, et je partis, accom-
“ pagne de plusieurs de mes eleves, pour
“ cette petite excursion mineralogique.

“ Deja de loin, j’appercu sur la mon-
“ tagne, ou plutot sur la sommité, une
“ echancrure assez considerable ; je comp-
“ tai bien trouver, dans cet endroit, la
“ roche a nud, et voir ainsi la structure de
“ l’interieur ; la suite fera voir que je
“ ne me trompais pas. Cependant je ne
“ croyais trouver ici qu’une couche de
“ fable environnant le pied de la som-
“ mité basaltique, comme l’on avait cru
“ generalement jusqu’ ici que c’etait le
“ cas au Pæhlberg, pres d’Annaberg.
“ Mais, quel fut mon etonnement des que

“ j’y arrivai ! au premier coup d’œil j’ap-
“ perçus une couche épaisse de *sable quart-*
“ *zeux* ; et, au-dessus, quelques *couches*
“ d’argile, enfin une *couche de wacke*,
“ sur laquelle le *basalte* reposait : avec
“ quel étonnement, je vis ces trois couches
“ s’étendre *presque horizontalement sous le*
“ *basalte*, et lui servir ainsi de support ;
“ le sable devenir de plus en plus fin, et
“ enfin argileux sur le haut ; de sorte
“ qu’il passait formellement à l’argile,
“ comme celle-ci passait également dans
“ sa partie supérieure à la wacke, et enfin
“ cette dernière substance au *basalte* ; en
“ un mot qu’on avait ici le passage le
“ plus parfait du sable le plus pur au
“ sable argileux, de celui-ci à l’argile
“ sablonneuse ; de là, par une suite gra-
“ duée de nuances, à l’argile grasse, à la
“ wacke, et enfin au *basalte*.

“ A cet aspect, il m’arriva ce qu’arri-
“ vera certainement à tout naturaliste qui
“ verra ce phénomène ; les idées se succe-
“ derent avec rapidité, et il me fut impossi-

“ ble de ne pas m'écrier : *ce basalte, cette*
“ *wacke, cette argile, ce sable, sont tous d'une*
“ *meme formation* ; toutes ces substances
“ sont des *sedimens*, des *precipités*, provenus
“ d'une *meme dissolution aqueuse* qui couv-
“ rait autrefois cette contrée : cette mer
“ charria d'abord le *sable* dans cet endroit ;
“ puis elle y deposa l'argile ; le sediment,
“ changeant peu a peu de nature, devint
“ ensuite de la *wacke*, et finalement un
“ vrai *basalte*.

“ Je ferai encore, au sujet de cette
“ observation, et en peu des mots, les
“ remarques suivantes : le basalte, dans
“ cette enchancrure, était divisé en
“ prismes presque verticaux, et distincte-
“ ment séparés les uns des autres : la
“ division prismatique allait jusques a la
“ couche de wacke, et se propageait dans
“ une partie de son épaisseur. Cette
“ wacke considérée en grand avait une
“ texture schisteuse. On ne pouvait pas
“ voir la partie inferieure de la couche
“ de sable, elle était recouverte par le

“ monceau de fable retiré de la mine :
“ mais ce fable devint de plus en plus
“ grossier, et il degenerait enfin en un
“ gravier a gros grains. Le gneis, qui
“ constitue la masse de la montagne tout
“ autour, paraissait a decouvert immédia-
“ tement au-dessous du monceau.

“ Je ne puis ici m'étendre plus au long
“ sur cette observation si remarquable :
“ j'en donnerai incessamment des de-
“ tails plus étendus. Que dira de ceci
“ la grande partie de nos mineralogistes,
“ si eprise de la volcanicité du basalte !

“ Quant a ce qui me concerne, je suis
“ entierement convaincu ; que *tous les*
“ *basaltes sont des produits de la voie humide,*
“ *et qu'ils sont d'une formation tres-recente.*
“ *Qu' autrefois ils formaient tous une grande*
“ *assise d'une immense étendue, qui recouvrait*
“ *des sols, primitifs et des sols secondaires ;*
“ *que l'action du tems en a de nouveau de-*
“ *truit une grand partie, et qui toutes les*
“ *sommités basaltiques en sont les restes.*

“ Je ferai bientôt part au public de
“ mon sentiment sur la nature et sur la
“ formation du basalte, et je lui expo-
“ serai toutes les raisons sur lesquelles il
“ est fondé.”

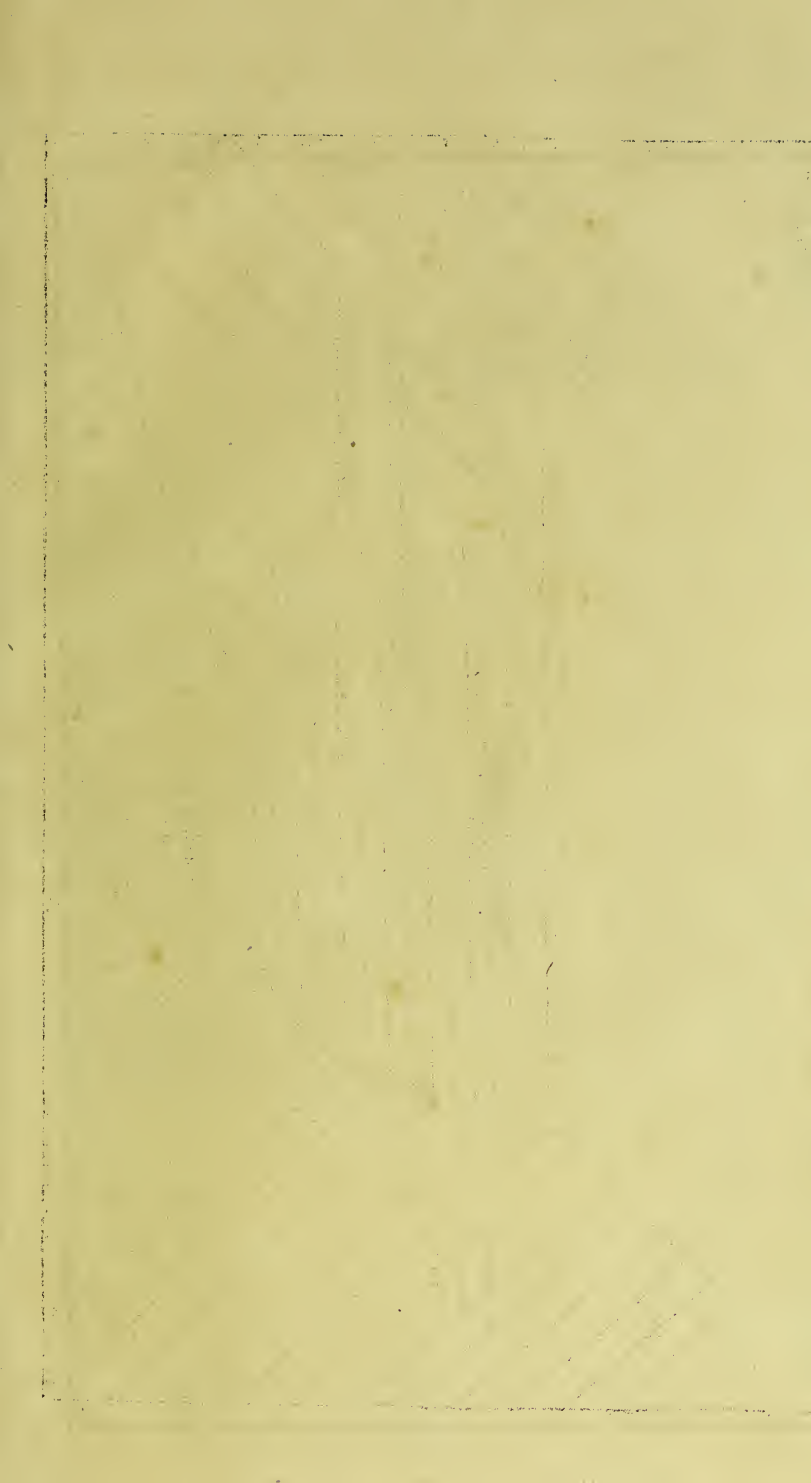
Freiberg, le 20 Octobre 1788.

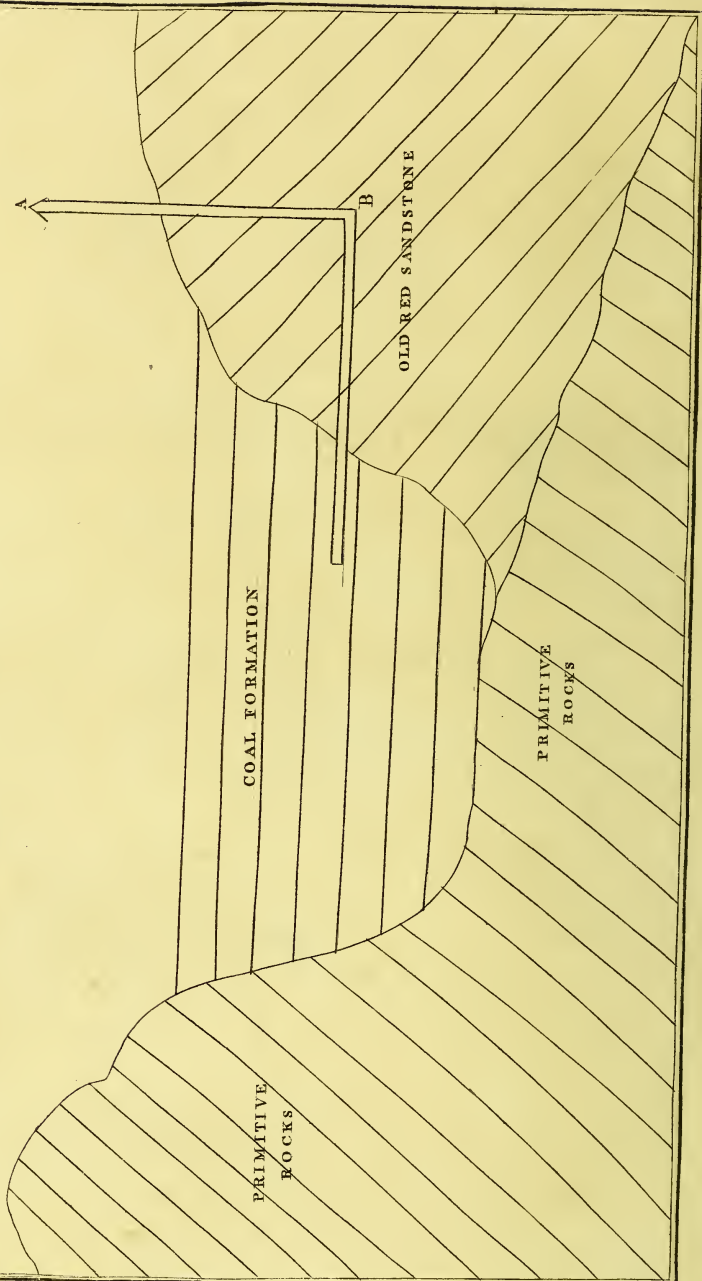
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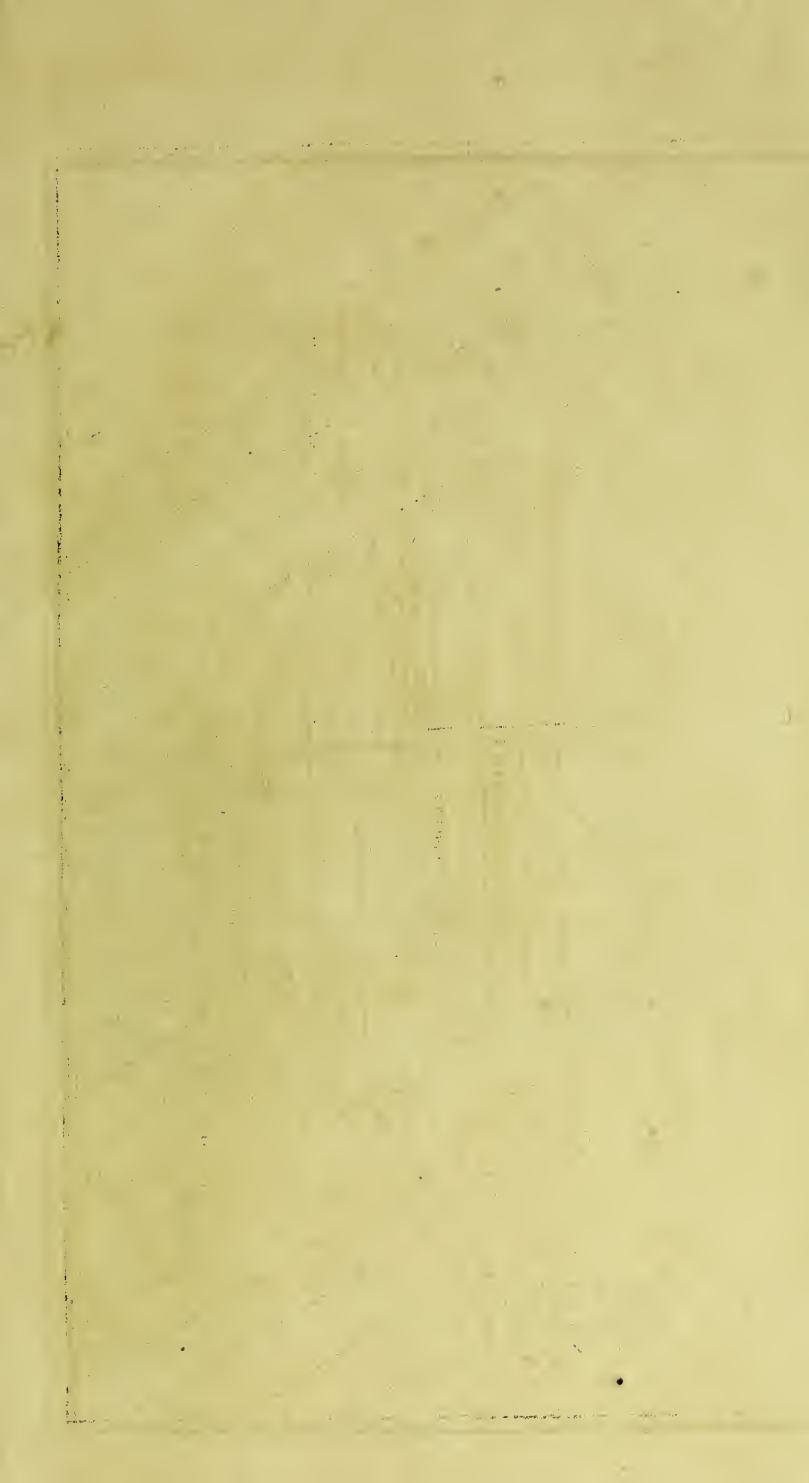
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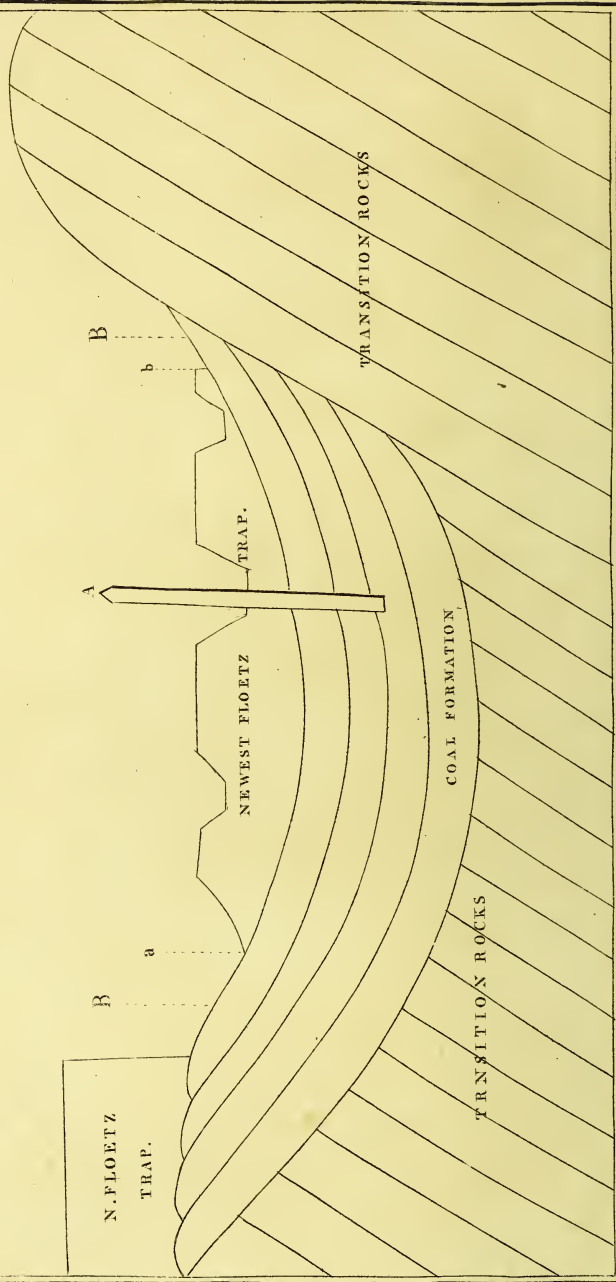
ERRATA.

Page	Line		
3	24	<i>for</i> 3300,	<i>read</i> 2200.
8	8	Annandale,	Nithsdale.
11	16	river,	rivers.
47	8	<i>after</i> find,	in it.
52	8	<i>of the note, the word strata to be omitted.</i>	
57	1	<i>for</i> sparry iron ore,	<i>read</i> sparry iron stone.
<i>id.</i>	2	brown iron ochre,	ochry brown iron stone.
74		<i>add</i> that from the year 1760 to 1798, this mine afforded 100 tons of regulus of antimony, valued at 84l. a ton, or 8400l.	
83	17	<i>for</i> village,	<i>read</i> town of Annan.
87	18	spot,	spots.
90		Brown muir inn,	Brown hill inn.
143		sandstone,	this sandstone.
153		Sir James Hall's observation not referring to stripes, to be cancelled.	
171	17	<i>for</i> floetz	<i>read</i> newest floetz-trap.









EXPLANATION OF PLATES.

PLATE I.

IN Plate 1, the coal formation is represented lying on transition rocks, and covered with the newest floetz-trap formation, excepting at B, where it appears at the surface, and can be traced under the floetz-trap rocks, which cover the whole district *a—b*. A shaft is sunk at A, as being the most eligible situation, and passes through the floetz-trap rocks into the coal formation. It also represents the relative geognostic situation of the different formations of which the county of Dumfries is composed. Illustrating case 1,

PLATE II.

Represents a shaft A sunk in the old red sandstone, and a gallery B from it into the coal formation illustrating Case 6.

PLATE III.

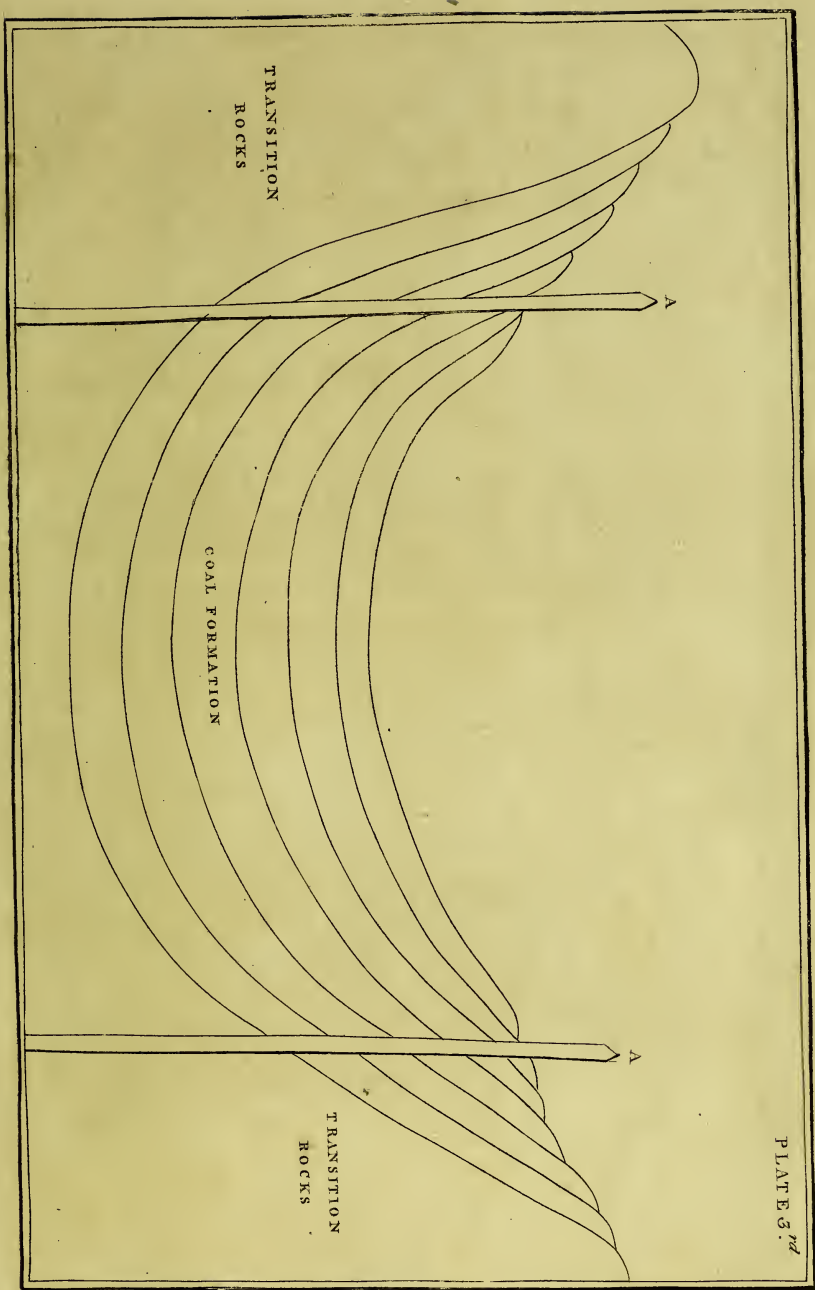
Two shafts are represented passing through the coal formation into the subjacent transition rocks which never contain coal ; illustrative of Case 9.

PLATE IV.

Fig. 1. Section of the country from the Solway frith to the frith of Forth, in which the mountainous country is composed of transition rocks, and the lower of rocks belonging to the coal formation.

Fig. 2. Represents the structure of the hill called Burnswark ; and also instances what I term the over-laying disposition of the stratification.

Fig. 3. Different parts of which a mountain is composed ; A foot, B acclivity, C summit.



SOLWAY FRITH



TRANSITION ROCKS

FRITH OF FORTH

FIG. 2.^d

BURNSWARK

N. FLOETZ TRAP

SANDSTONE

TRANSITION ROCKS

FIG. 3.^d

C

B

A.

